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TR 415

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Volume 1

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FINAL REPORT

NOVEMBER 30, 1977

VOLUME I

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FINAL REPORT

NOVEMBER 30, 1977

WRITTEN BY: B. A. Wilson — B. A. WILSON, CHIEF ENGINEER DATE: Nov. 23rd 1977

APPROVED BY: J. R. Baker — J. R. BAKER, GENERAL MANAGER DATE: 11-23-77

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TABLE i

GLOSSARY OF ABBREVIATIONS AND TERMS

ADI	=	Assembly Disassembly Instructions
CHS	=	Collimated Hole Structure
cm	=	centimeter
cm^2	=	Square centimeter
DCT	=	Design Certification Test
EVA	=	Extravehicular activity
GBR	=	Glass Bead Rating
GN_2	=	Gaseous Nitrogen
H_2O	=	Water
HPOF	=	High Pressure Oxygen Filter
hr	=	hour
IBP	=	Initial Bubble Point
JSC	=	Johnson Space Center
Kg	=	Killogram
lbs	=	Pounds
min	=	Minute
NASA	=	National Aeronautics and Space Administration
OPS	=	Oxygen Purge System
psi	=	pounds per square inch
psia	=	pounds per square inch absolute
psid	=	pounds per square inch differential
psig	=	pounds per square inch gauge
scfm	=	standard cubic feet per minute
S/N	=	Serial Number
SOP	=	Secondary Oxygen Pack

TABLE i (cont.)

sq = square

TIG = Tungsten Inert Gas

WSTF = White Sands Test Facility

TABLE ii

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SECTION 1

INTRODUCTION

The experience of the National Aeronautics and Space Administration (NASA) with extravehicular activity (EVA) life support emergency oxygen supply subsystems has shown a large number of problems associated with particulate contamination. These problems have resulted in failures of high pressure oxygen component sealing surfaces. The resulting failure analysis and investigative research indicated the need for a development program to create a filter which would protect the sealing surfaces in shutoff valves and pressure regulators from exposure to particulate contamination above 10 microns absolute rating. Beyond the normal filtration capability, the developed filter would be required to withstand the dynamic loading resulting from the instantaneous pressurization from ambient to 6000 to 8000 psi when the shutoff valve is opened. This dynamic loading represents a unique condition which makes standard filter technology as developed for the conventional constant flow situation inadequate.

The filter resulting from the program will be utilized in the emergency astronaut oxygen subsystems for the Space Shuttle Program.

SECTION 2

SUMMARY

A program was completed to develop a new design of high pressure oxygen filter which would:

a) control the particulate contamination level in the oxygen system to a 5 micron Glass Bead Rating (GBR) 10 micron absolute condition.

b) withstand the dynamic shock condition resulting from the sudden opening of 8000 psi oxygen system shutoff valve.

The program was divided into seven separate tasks as follows:

1. Contaminant Source Identification Tests
2. Dynamic System Tests
3. HPOF Concept Evaluation
4. Design
5. Fabrication
6. Test
7. Application Demonstration

During Task 1, two NASA furnished oxygen systems, the Apollo OPS (oxygen purge system) and the Skylab SOP (secondary oxygen pack) were disassembled and flushed and the entrained contaminants collected, weighed and analyzed. This data was used by NASA to guide the preparation of cleanliness specifications for the Space Shuttle systems. This also gave the data necessary to determine the required contaminant tolerance of the HPOF design. The accumulated contaminant was analyzed physically and chemically by the Propulsion Laboratory at the NASA White Sands Test Facility (WSTF), Las Cruces, New Mexico.

For Task 2, the SOP and OPS systems were reassembled,

modified and instrumented to permit actual blowdown tests. From these tests, the magnitude and duration of the dynamic pressure spike was determined. This established the structural design criteria for the HPOF.

Task 3 encompassed the evaluation of a group of concepts for the HPOF with respect to the performance criteria established prior to the program and also by the data accumulated during Tasks 1 and 2. The study resulted in a ranking of the concepts in order of preference. From this work, the suggested prime alternates were presented to NASA for review and approval. Following selection of the final concept, the system was optimized and a detailed problem statement was prepared based on the detailed characteristics of the filter.

The complete design of the selected concept was performed during Task 4 in two stages. Preliminary design was based on the problem statement and consisted of preliminary layouts for NASA review. Following approval, the Final Design phase was initiated. Detail and assembly drawings were prepared, together with a precise bill of material, fabrication process specifications and manufacturing planning documents. The design package was approved by NASA prior to engineering release of the test articles for fabrication.

The fabrication sequence was Task 5 of this program and was completed successfully, but not without incident. Difficulties with the electron beam welding process required several changes in the design from a manufacturing standpoint. The basic design concept, however, was not changed.

Task 6 involved the largest single phase of the program, that of acceptance and certification testing. An overall certification test plan and acceptance test procedure were prepared and approved. Acceptance tests were performed at Wintec, while the extensive certification test program was performed at the NASA White Sands Test Facility. A detailed test plan for the certification tests was prepared by NASA and coordinated with Wintec. The certification test program was a lengthy and exhaustive sequence which thoroughly proved the adequacy of the HPOF design. The results of the test series were presented to NASA, JSC, Houston and published in detail in NASA WSTF Document No. TR-121-026, dated November 15, 1976. In view of the physical size of this NASA document, it will not be incorporated into this report. It has been distributed under separate cover to the designated addressees and will be referred to when necessary in this report.

The final phase of this program was involved with an application demonstration of the qualified HPOF. An SOP fill and shutoff valve was provided for the demonstration. The valve was modified to receive three of the HPOF assemblies in place of the existing three pleated filter discs. Following assembly, the valve was shipped to NASA JSC, Houston for evaluation.

SECTION 3

CONTAMINANT SOURCE IDENTIFICATION TESTS

3.1 GENERAL

In order to identify and quantify the contaminant contained in a typical oxygen breathing system, two emergency systems were supplied by NASA for examination. Following a thorough evaluation of the hardware and assembly and detail drawings, disassembly procedures were prepared for each of the systems.

Wintec procedure number ADI 730101 was prepared covering disassembly and flushing of the Apollo Oxygen Purge System (OPS) Hamilton Standard P/N SV 730101-3-10. This procedure was reviewed and approved at a coordination meeting at NASA Johnson Spacecraft Center (JSC) Houston. A copy of the procedure is included as Appendix A to this report. Wintec procedure number ADI 132730 was prepared, covering disassembly and flushing of the Skylab Secondary Oxygen Pack (SOP) Airesearch P/N 132730. This procedure was also reviewed and approved at the coordination meeting. A copy of this procedure is included in Appendix A.

3.2 DISASSEMBLY AND FLUSHING OF OPS

Disassembly of the OPS commenced in accordance with the approved procedure. Preliminary work was performed in a laminar flow bench. The covers, antenna, hoses, actuator and

all the ancilliary equipment were removed. The unit was moved into the Wintec Clean Room for final disassembly and flushing of the components.

The OPS system was completely disassembled to permit removal of the valve-regulator housing. The valve was removed from the housing and the housing was flushed with freon to collect in-situ contaminant for analysis. The housing was modified to accomodate pressure taps for the transient pressure analysis.

The valve assembly, components and tanks were flushed thoroughly with freon. The freon was flushed through silver membranes and these, together with a blank sample membrane were forwarded to NASA White Sands Test Facility (WSTF) for analysis.

In removing the plugs from the bottom of the oxygen tanks, prior to flushing, it was found that some of the "O" rings were broken and some of the Delta seals were distorted due apparently to incorrect assembly. This condition was noted in the historical record for the unit and replacement seals were requested from NASA JSC. The original seals were forwarded to NASA JSC for examination.

New O-ring kits for the tank plugs were received from NASA. The tanks were reassembled using these seal kits. In re-assembling the control valve, it was determined that special tools would be required. Upon checking, these were not available from Hamilton Standard, Carleton Controls, or NASA. The tools were manufactured by Wintec using refer-

ence drawings from Carleton Controls. Using these tools, the re-assembly of the OPS was readily accomplished in preparation for the series of transient pressure analysis tests.

3-3 DISASSEMBLY AND FLUSHING OF SOP

Disassembly of the SOP was performed in accordance with the approved procedure. Preliminary work was performed in a laminar flow bench. Exterior fabric cover and protective shell were removed. Structural housing components and thermocouple wires were also removed, leaving the system ready for transfer into the Wintec Clean Room for final disassembly and flushing of the components.

The SOP system was partially disassembled to permit removal of the connection tubing. One of the pressure bottles was removed to facilitate the tube removal. The tubes were flushed with freon to collect in-situ contaminant for analysis. The tubes were then cut and special tees were welded in place to hold the pressure transducers for the transient pressure analysis.

The system was re-assembled and prepared for the transient pressure analysis testing. This sequence of tests is described in detail in Section 4 of this report.

3-4 MEMBRANE PARTICLE COUNTING

Aluminum mounting blocks were obtained from NASA WSTF for mounting silver membranes. A styrofoam handling and shipping container was designed and procured. In consultation with NASA WSTF, a procedure (WSP 043) was written

covering the mounting and general handling of the silver membranes. A copy of this procedure is included as Appendix B to this report.

Blank "background" membranes and initial flushing membranes from the SOP and OPS were prepared and preliminary particle counts were made by Wintec. These membranes were ready for shipment to NASA WSTF for analysis, however, some difficulty was experienced in bonding the membranes to the aluminum support blocks. These difficulties were solved in consultation with NASA WSTF. A slight variation in the adhesive mix corrected the problem.

The SOP collection membranes were counted using routine statistical techniques. These results showed the regulator and tanks to be highly contaminated with the valve running third. The particle counts are shown in Table I.

The membranes from the flushing of the OPS system were counted for metallic and non-metallic particles. The resulting counts are shown in Table I. These results were forwarded to NASA WSTF with the membranes.

3-5 PARTICULATE ANALYSIS AT NASA JSC, WHITE SANDS

The initial specimen membranes were received at WSTF and a preliminary analysis was performed. As a result of the analysis, a modification was made to Wintec Procedure WSP-043 for packaging and shipping the membranes. The initial membranes were received at WSTF with significant quantities of styrofoam powder on the membrane surface, apparently from vibration of the packaging block.

The detailed analysis of the specimen membranes resulted in a much more comprehensive program than had originally been anticipated. A wealth of data was accumulated on a wide variety of particles. The majority of particles, however, were teflon.

All of the analysis details and particulate photographs were compiled in two volumes of data as NASA WSTF Report No. TPS3-HPF-001. A copy of each of these volumes has been distributed to JSC Houston and Wintec. The third copy remains in the JSC WSTF Propulsion Test Office. In view of the voluminous nature of this document, copies are not included with this report.

A typical analysis of a single particle and a photograph of the particle are shown in Table II and Figure 1 respectively. A copy of all the summarized analytical data is contained in Appendix C. The final result of the analysis is contained in Table III and presents the suggested synthetic contaminant for the contaminant tolerance tests of the HPOF. JSC WSTF attempted to have this contaminant synthesized but found this to be impossible within the schedule constraints of the program. Several sources were pursued with no success. Consideration was given to creating a proportionate mix of available standard contaminants and this was finally adopted as a substitute contaminant.

TABLE I

PARTICLE COUNTS FOR OPS MEMBRANES

ITEM	PARTICLE 25-50	51-100	100-250	>250
Valve Details				
Non Metallic	2880	1360	118	35
Metallic	4	4	1	0
Tanks				
Non Metallic	1860	480	8	2
Metallic	2	3	0	0
Valve/Regulator Housing				
Non Metallic	40	38	4	6
Metallic	0	0	1	0
Blank Count	16	0	0	0

PARTICLE COUNTS FOR SOP MEMBRANES

ITEM	25-50	51-100	100-250	>250
Valve Tubes				
Non Metallic	15	11	5	1
Metallic	0	0	0	0
Valve Assembly				
Non Metallic	160	34	6	2
Metallic	7	3	0	0
Housing Assembly				
Non Metallic	390	140	24	9
Metallic	15	8	3	1
Misc. Tubes				
Non Metallic	40	19	7	4
Metallic	6	3	0	0
Tanks				
Non Metallic	6800	460	60	22
Metallic	19	8	1	0
Regulator				
Non Metallic	8800	580	70	29
Metallic	80	21	18	6
Blank Count	4	0	0	0

SECTION 4

TRANSIENT PRESSURE ANALYSIS

4-1 DESIGN OF TEST SYSTEMS

In conjunction with NASA WSTF, the major items of test instrumentation were selected to provide data with the required degree of accuracy. High frequency Kistler transducers were specified and ordered with special fittings for system adaptation. Charge amplifiers (Unholtz-Dickie) were provided by NASA. The electronic output system was designed and components specified.

Some high pressure tubing and fittings were procured and the balance of the fittings were specified as items to be manufactured. Detail design of these latter items was performed.

The last part of the design phase consisted of a modification to the OPS and SOP systems to permit pressure measurement at the critical zones in the system.

An additional monitoring channel was added to the oscilloscope and a camera was specified for use with the scope.

4-2 PROCUREMENT OF INSTRUMENTATION

The high frequency transducers and associated fittings and connecting cables were procured. High pressure standard fittings and tubing were purchased.

4-3 MANUFACTURE OF SPECIAL FITTINGS

All of the machining for the special fittings was performed by Wintec.

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FIGURE I
TYPICAL PARTICLE (1000 x mag.)

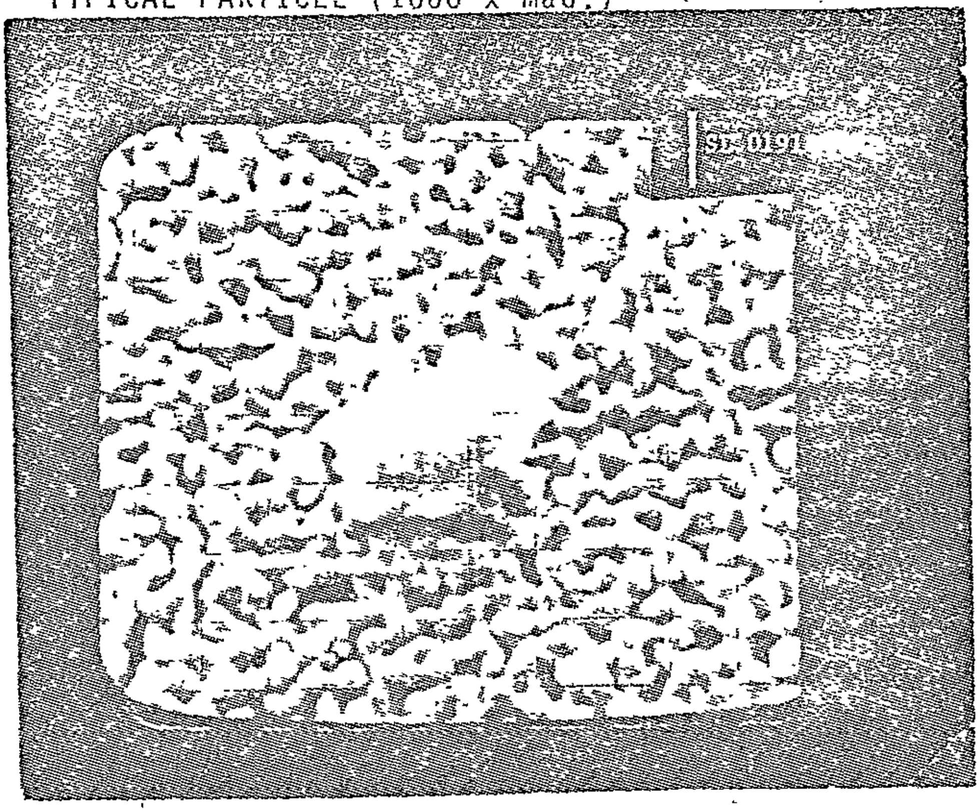

TABLE II

Sample: SOP Valve

Magnification: 1000X
1 division = 10 microns

Particle Size: 50u x 30u

Relative abundance of elements detected:

Cr	Fe	Ni	Cu	Zn
.28	2.45	.40	.25	.41

Si	Ca	Al	C
6.61	.05	1.18	88.36

TABLE III

SUGGESTED SYNTHETIC CONTAMINANT

PARTICLE TYPE	PERCENT BY WEIGHT DERIVED FROM OPS AND SOP DATA	 PROPOSED MIXTURE
TFE TEFLON	34	56
PLASTIC	17	--
SAND	23	19
STAINLESS STEEL	26	25

SIZE RANGE OF CONTAMINANT	DERIVED FROM OPS AND SOP DATA	PROPOSED MIXTURE
< 15	41	49
16-25	3	13
26-50	3	10
51-100	21	7
> 100	32	21

TABLE III (CONT)

SUGGESTED SYNTHETIC CONTAMINANT

TOTAL NO. OF PARTICLES PER MIX

SIZE RANGE (MICRONS)	STAINLESS STEEL	SAND	Fe_3O_4	TFE TEFLON	TOTAL NO.
< 15	0.855×10^8	0.855×10^8	0.855×10^8	5.315×10^8	7.88×10^8
16-25	1.476×10^6	1.476×10^6	1.476×10^6	5.592×10^6	1.002×10^6
26-50	1.4254×10^5	1.523×10^5	1.035×10^5	8.593×10^5	1.25764×10^6
51-100	2.326×10^4	2.744×10^4	6.54×10^3	4.906×10^4	1.063×10^5
> 100	1.364×10^4	1.705×10^4	0	1.025×10^4	4.094×10^4

TOTAL WEIGHT OF PARTICLES PER MIX

SIZE RANGE (MICRONS)	STAINLESS STEEL	SAND	FE_3O_4	TFE TEFLON	TOTAL WEIGHT IN SIZE RANGE (GRAMS)	% BY WEIGHT IN SIZE RANGE
< 15	0.04724	0.04724	0.04724	0.29365	0.43537	49.5
16-25	0.01664	0.01664	0.01664	0.06305	0.11297	12.8
26-50	0.01023	0.01093	0.00743	0.06165	0.09024	10.3
51-100	0.01308	0.01544	0.00368	0.02760	0.05980	6.8
> 100	0.06036	0.07545	0	0.04536	0.18117	20.6
TOTAL WEIGHT OF MATERIAL (GRAMS)	0.14755	0.16570	0.07499	0.49131		
% BY WEIGHT	16.8	18.8	8.5	55.8		

IF THE FE_3O_4 IS CONSIDERED TO BE STAINLESS STEEL, THE % BY WEIGHT FIGURES CHANGE TO:

STAINLESS STEEL: 25.3 % SAND: 18.8% TFE TEFLON: 55.8%

4-3 MANUFACTURE OF SPECIAL FITTINGS. (cont.)

The SOP System tubing was modified to accept the fittings which were then welded in place and the system reassembled. The SOP system was then proof tested to 10,000 psi and loaded to 6000 psi with GN_2 ready for test.

The OPS valve and regulator housing was modified to permit incorporation of the Kistler transducer fittings. This modification required installation of a plug in the gauge sensing port.

4-4 TEST SET-UP

The schematics for the test set-up were reviewed and the recording instrumentation was specified and obtained from an instrumentation leasing company.

The test set-up was completed and preliminary low pressure (~2000 psi) tests were run. The preliminary tests showed that the pressure spikes are readily obtained.

The test set-up was completed with the addition of the oscilloscope camera and an additional monitoring channel. Some problems were encountered in the calibration of the oscillograph and oscilloscope in relation to the charge amplifier output. These problems were resolved with the assistance of WSTF test personnel.

4-5 SYSTEM TEST

The SOP system was reloaded to 6000 PSI and several system actuations were recorded. The most significant pressure spike occurs as anticipated, in the line between the valve and the regulator. The spike in this location is accentuated by the fact that this feed line is initially

at atmospheric pressure.

Spike data was recorded on the oscillograph tape and also photographed from the oscilloscope. A typical oscillograph spike is shown in Figure 2 with the oscilloscope trace in Figure 3.

The test set-up is shown in Figure 4 and a close up of the SOP showing transducer installation locations is shown in Figure 5. Transducer #1 was located in the line leading from the outlet of the valve to the inlet of the regulator. This line is initially at atmospheric pressure and sees full system pressure when the valve is opened. The most severe pressure spike will occur in this line. Referring to Figure 6 which a cross section of the shutoff valve, this spike will be experienced by the filter in location #1. The oscilloscope trace of this spike is shown in Figure 3(a).

Transducer #2 is mounted in a special fitting located in the high pressure gage port of the valve. This transducer is initially at 6000 PSIG hence when the valve opens, the pressure is initially reduced. As the pressure recovers, a small positive spike occurs. This is from the return reflection of the pressure spike caused when the valve opens. This spike is reflected back from the regulator, and is dampened by line and bend losses and also by Filter #1 (ref. Figure 6). This pressure transient spike will be experienced by the inlet filter at location #2 of the valve (ref. Figure 6). It should be noted here that the filter at

location #3 in the valve is only used during the fill process to filter entrant gas.

The schematic of the test set-up is shown in Figure 7.

Transducer #3 is located in the line between the tanks and the shutoff valve. This line is also initially at 6000 PSIG hence when the valve opens, the pressure initially reduces and a negative spike occurs. Since this transducer is the closest one to the supply tanks, the magnitude of the negative spike is minimal and upon recovery, no positive spike occurs. The oscilloscope trace of this spike is shown in Figure 3C. In referring to the valve, Figure 6, this spike is an entrance condition only and will not affect any of the filters located internally in the valve.

Tests were also run on the OPS system and excellent data was obtained. Figure 8 shows the typical trace obtained from the monitoring oscillograph. In this particular test series, the design of the OPS unit dictated monitoring pressure in only two locations.

The pressure spikes were also monitored by oscilloscope and the trace photographed. A copy of the photographic record is shown as Figure 9.

The test series was run using a series of differing values of sensitivity set on the charge amplifier. Photographs of this series were rather poor in quality and hence are not presented in this report.

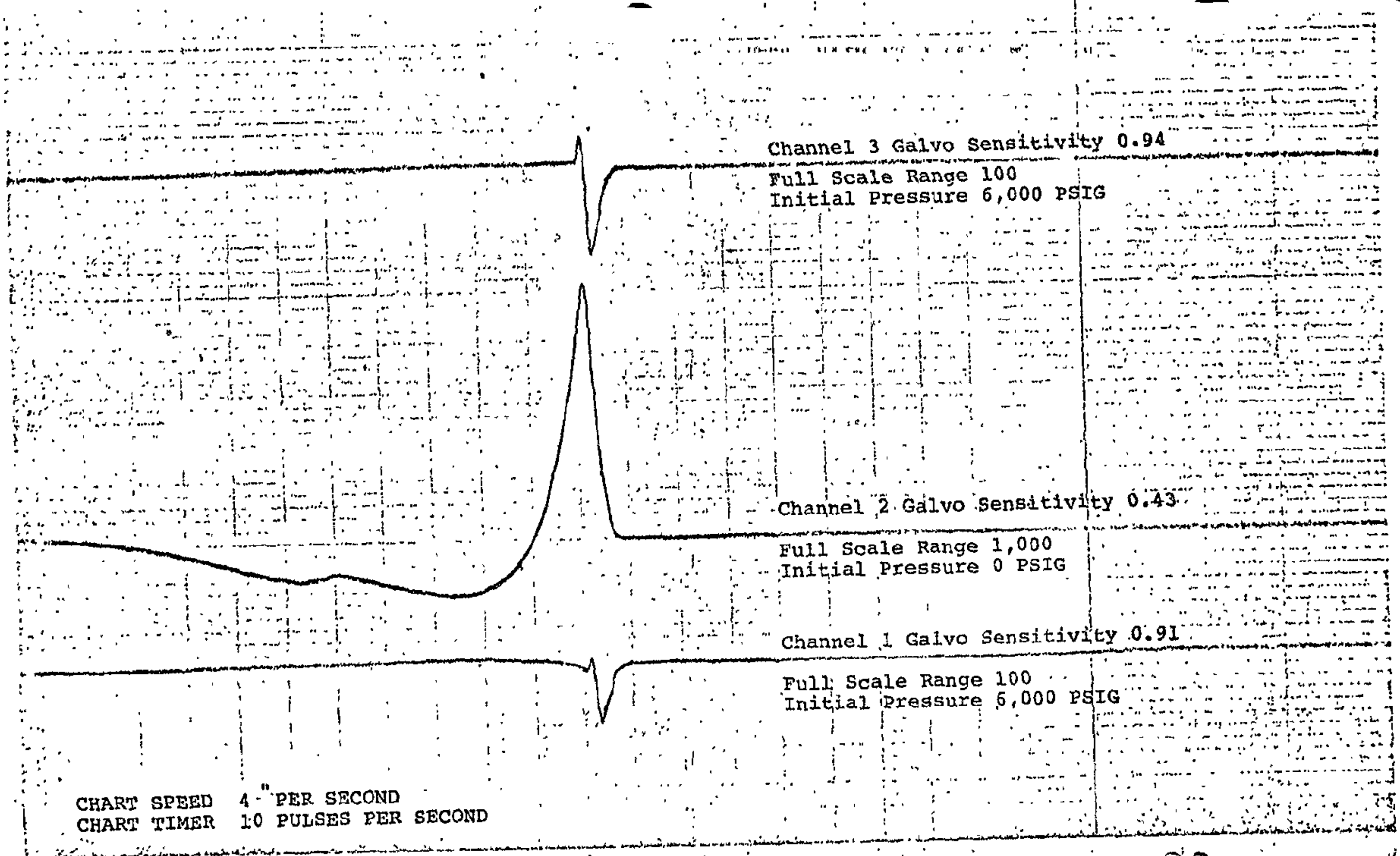

FIGURE 2. TYPICAL OSCILLOGRAPH TRACE

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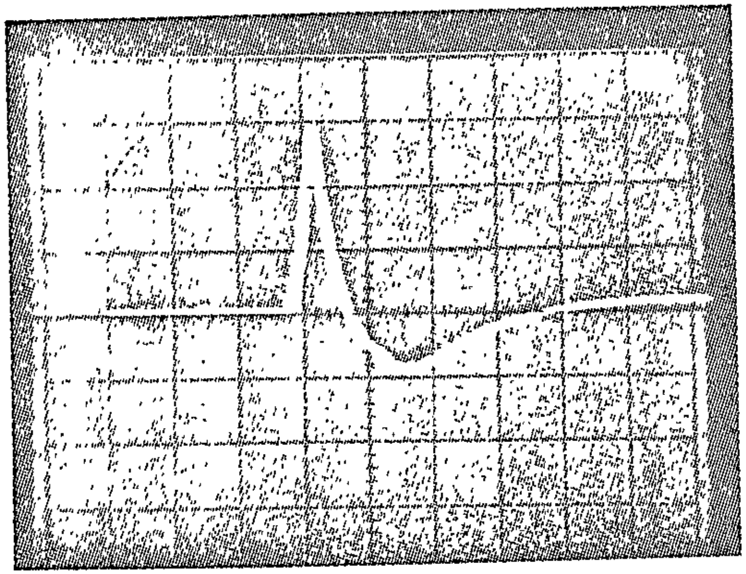
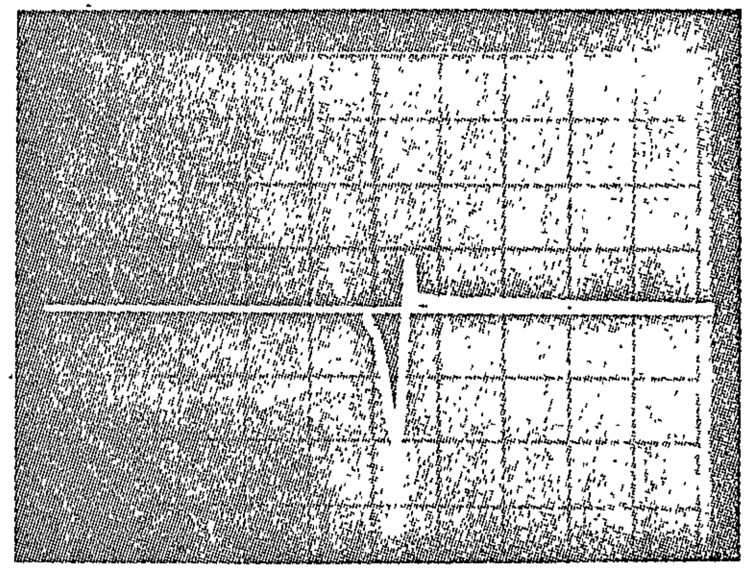


a) Channel #II
Initial Press. 0 PSIG
Charge Amplifier:-
Full Scale 1000
Output Gain 4.0
Oscilloscope:-
Horiz. 0.2 secs/division
Vert. 5 volts/division



b) Channel #III
Initial Press. 6000 PSIG
Charge Amplifier:-
Full Scale 30
Output Gain 5.0
Oscilloscope:-
Horiz. 0.1 secs/division
Vert. 5 volts/division

FIGURE 3

OSCILLOSCOPE TRACES OF PRESSURE SPIKES

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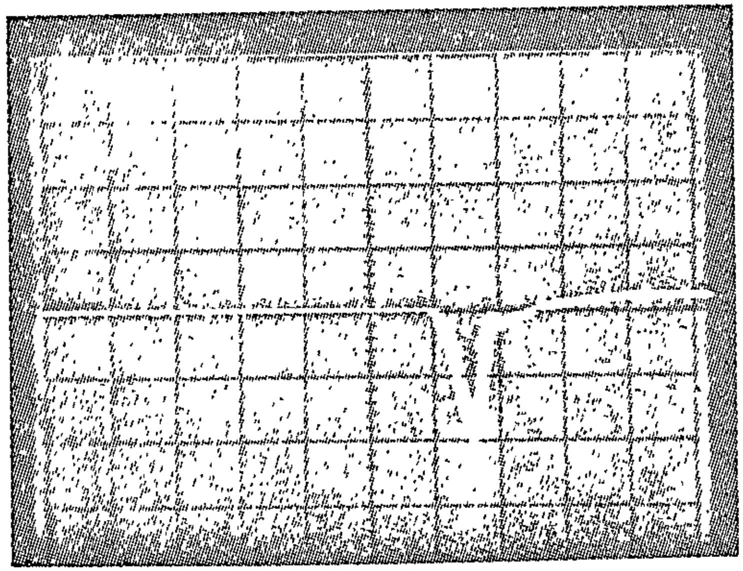

c) Channel # I
Initial Press 6000 PSIG
Charge Amplifier:-
Full Scale 30
Output Gain 10.0
Oscilloscope:-
Horiz. 0.1 secs/division
Vert. 5 volts/division

FIGURE 3 (cont.)

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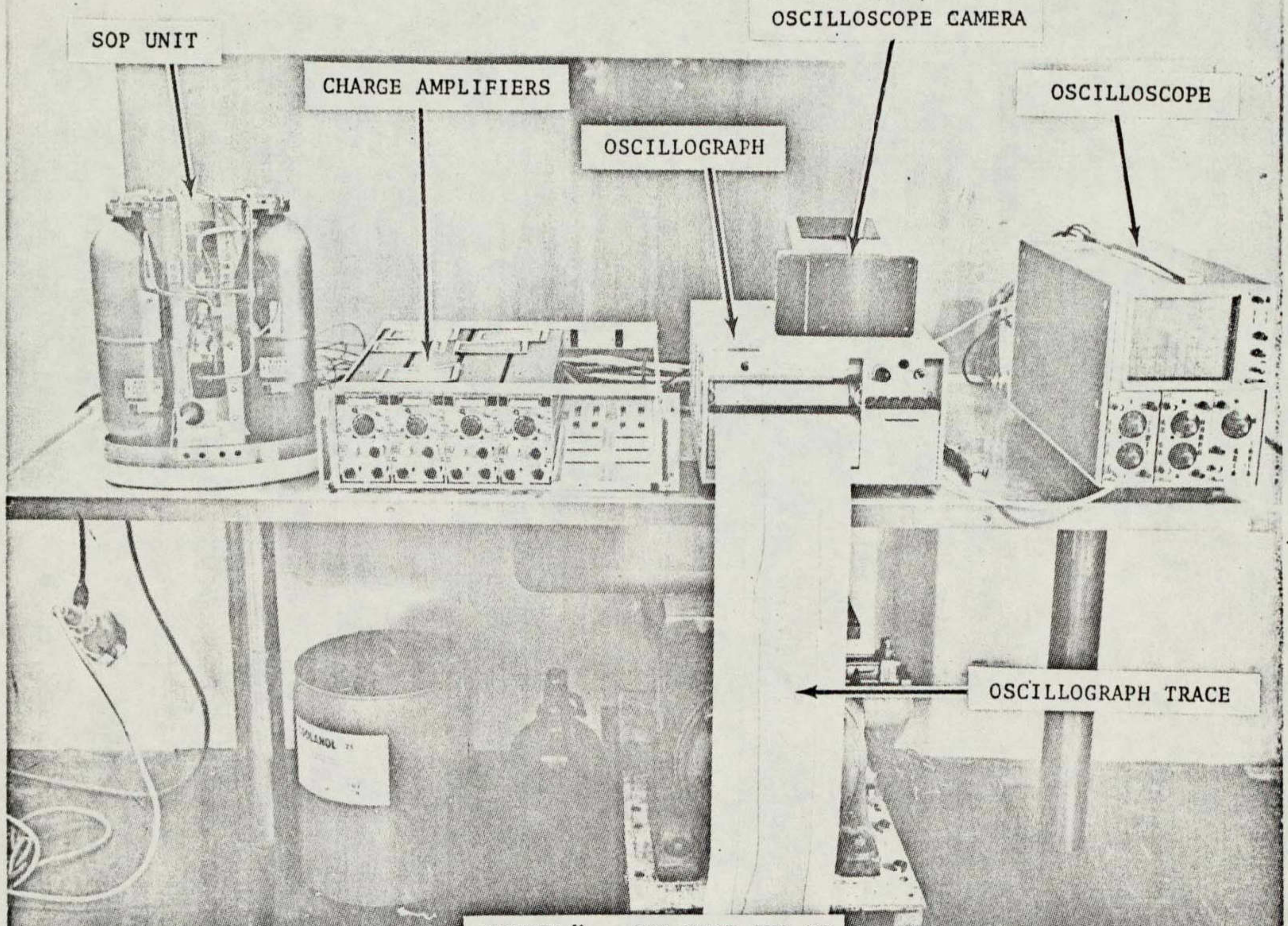

FIGURE 4 SOP TEST SET-UP

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BRUNSWICK

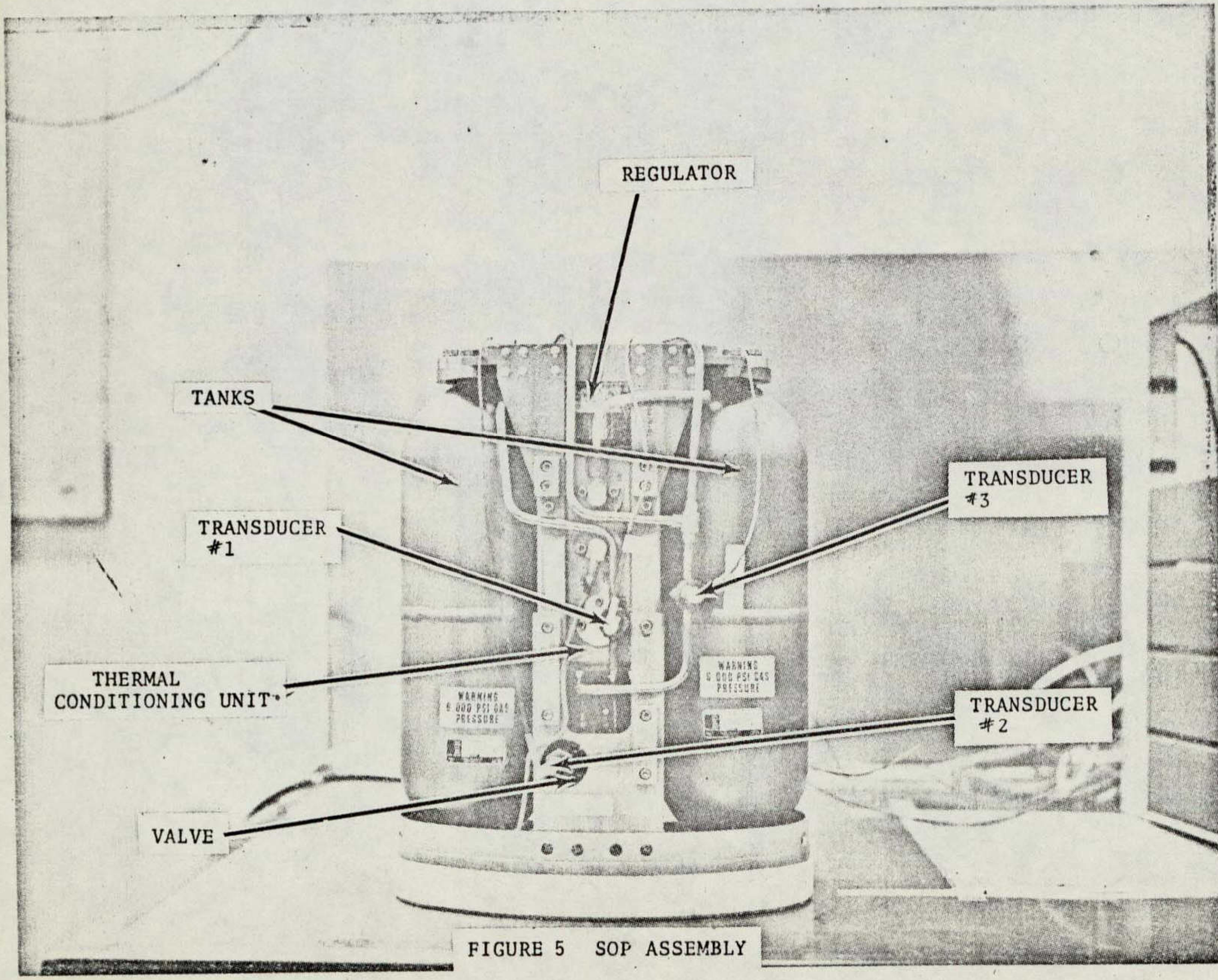

FIGURE 5 SOP ASSEMBLY

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BRUNSWICK

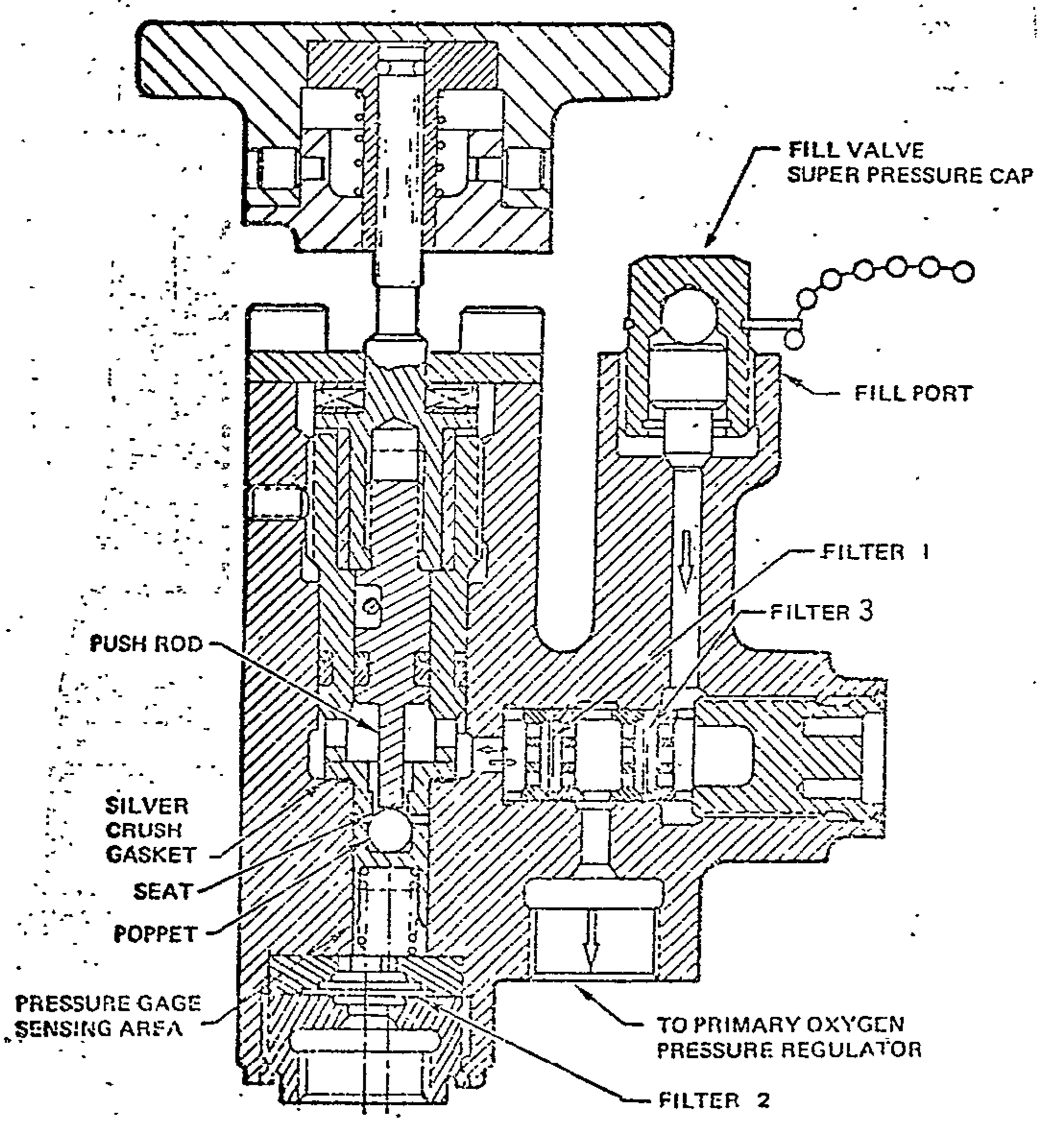

FIGURE 6
FILL AND SHUTOFF VALVE

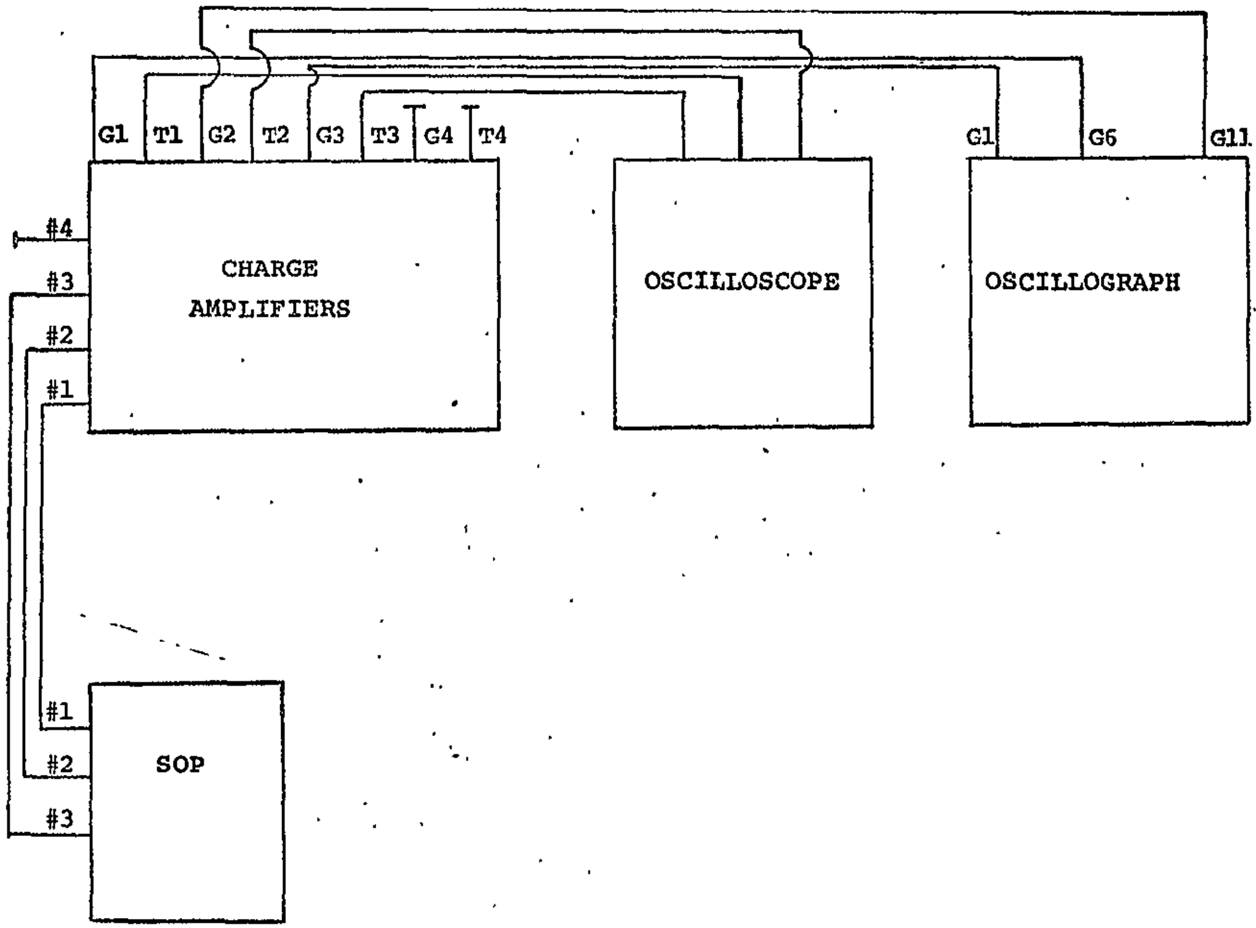

FIGURE 7 SOP TEST SCHEMATIC

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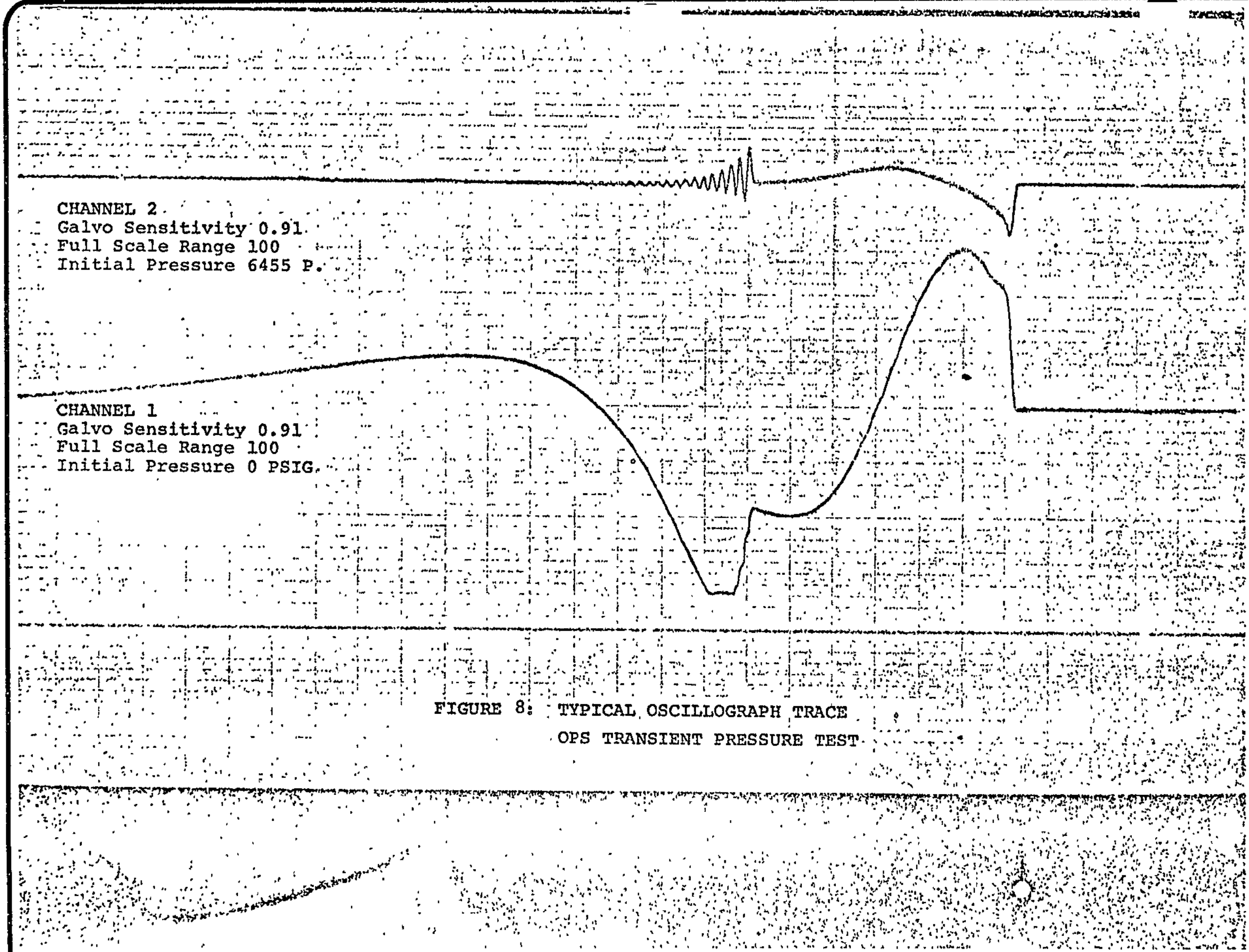

FIGURE 8: TYPICAL OSCILLOGRAPH TRACE
OPS TRANSIENT PRESSURE TEST

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FIGURE 9

OSCILLOSCOPE TRACE OF
OPS PRESSURE SPIKE

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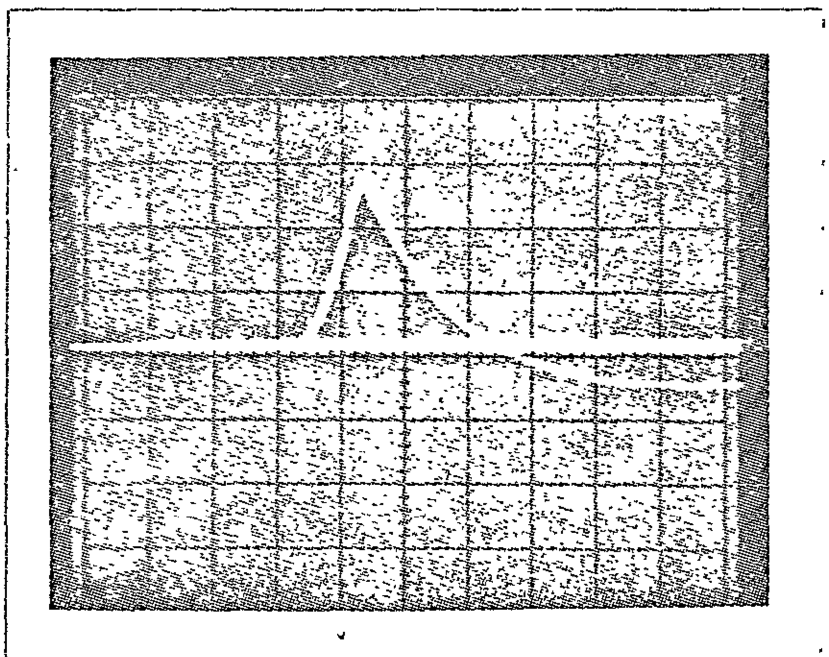

Initial Pressure: -
  6455 PSIG
Charge Amplifier: -
  Full Scale 100
  Output Gain 0
  Sensitivity 6.54
Oscilloscope: -
  10 mv/cm Pressure
  .2 secs./cm Time

4-6 DATA REDUCTION

A problem was encountered in the data reduction process. This problem related to the obtaining of the amplification factor for the pressure spike. The problem was discussed in depth the NASA WSTF data reduction and test personnel. An analog simulation was performed which reproduced the pressure spike condition from the SOP tests. The most plausible explanation of the unexpectedly low spikes was that the charge amplifier was saturated.

This was verified by altering the sensitivity settings on the charge amplifier for the OPS. Satisfactory readings were obtained and this permitted calibration of the SOP data.

Data reduction was completed for the OPS and the results are presented in Table IV.

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TABLE IV

OPS TRANSIENT PRESSURE TESTS DATA SUMMARY

INLET PRESSURE (PSIG)	FULL SCALE (CHARGE AMP)	SENSITIVITY	RANGE MULTIPLE	OSCILLOGRAPH SPIKE	TIME		SPIKE PSIG	SPIKE INLET	SPIKE REF: 6000 PSIG INLET (PSIG)
					INITIAL 70%	FULL SCALE			
6,000	100	6.54	60	14.2	20	120	8,529	1.42	8,520
6,455	100	6.54	60	16.7	20	120	10,020	1.55	9,300
5,450	100	5.45	50	17.8	20	120	8,900	1.63	9,780
6,850	300	4.36	40	10.0	25	150	12,000	1.75	10,500
6,450	300	3.27	30	13.0	25	140	11,700	1.81	10,860
6,250	300	2.18	20	18.0	25	125	10,800	1.72	10,320
5,950	1000	1.09	10	10.0	25	125	10,000	1.68	10,080
5,400	100	9.81	90	10.5	25	125	9,450	1.75	10,500

SECTION 5

CONCEPT EVALUATION

5-1 CONCEPT STUDY

The current SOP valve design was studied with particular attention paid to the present filter location. While the eventual selected filter design may be used in a variety of system locations, the demonstrated application will be in this particular valve, hence, the design will be initially tailored to fit this envelope.

Candidate filter media were listed for review and evaluation. The four primary filter media considered are described in the following paragraphs.

i) Dynalloy

This sintered, metallic fiber material is a proprietary product of the Brunswick Corporation and is available in several grades of stainless steel and many of the super-alloys to suit the particular application. Fiber sizes range down to 4 microns in diameter and the material is fabricated in sheet form. The sintered structure is a randomly oriented web of the fibers and has high strength even at low densities. Its significant sheet thickness relative to viber diameter gives Dynalloy excellent contamination tolerance characteristics.

ii) Wire Cloth

The wire cloth used in the manufacture of filter elements is of a type known as "Dutch Weave" and is distinguished from the more common square mesh weaves by greater

strength and tighter triangular shaped pores. Plain Dutch Single Weave and Reverse Dutch Single Weave and Twilled Dutch Single Weave have pores which allow direct light transmission at almost a 90^{0} angle and thus are not capable of removing fibers to the extent of the Twilled Dutch Double Weave Material which has the following characteristics:

a) Twice as many shute wires of the same diameter per linear inch.

b) A warped or bent triangular pore configuration which allows only diffused light transmission at approximately 30^{0} angles from the surface and which creates a tortuous flow passage through the cloth.

c) A so called "tight" weave which by means of compression of the shute wires prevents lateral movement or shifting of the wires in relation to one another.

For these reasons and also because it has the finest filtration rating of all the Dutch Weave cloths, Twilled Dutch Double Weave material will be one of the conceptual study candidates.

iii. Sintered, Laminated Mesh

This material is a composite sandwich of several layers of stainless steel wire cloth. The layers are rolled or "calendared" to a required thickness and porosity and the composite is then sintered to bond the layers together. The material is very strong and its filtration characteristics can be "tailored" to a system requirement by variations in the types and porosities of wire cloth used in

the combination. It is recognized that the sintering operation required to manufacture this type of medium is in violation of the requirements of SE-F-0044 as applied to wire mesh.

iv. Collimated Hole Structures (CHS)

This unique material is a proprietary product of the Brunswick Corporation. It consists of a stainless steel disc containing a multitude of small holes. The holes are of equal area to a high degree of precision and are exactly parallel (collimated) and perpendicular to the disc surface. As many as 500,000 holes can be placed in a 5/8 inch diameter disc with each hole having a diameter of 4 to 6 microns. The discs have a high strength and are very precise in their filtration rating. Since the pores or "holes" are of the "straight through" variety, contamination is not trapped in pores but rather builds up as a "cake" on the surface of the disc. Cleaning of a disc to original condition is thus a very simple process.

CHS has a very high mechanical strength which gives excellent shock resistance and eliminates the need for structural support in this application. Open area is in the range of 50 to 65%, giving minimum pressure drop under a given set of flow conditions. In its regular form, CHS has a solid outer, annular ring which readily facilitates installation and sealing. Use of CHS in this type of filter application will probably require the in-

corporation of a layer of wire cloth or Dynalloy to give the required absolute rating for any dimension of particle.

The review process was initiated and preliminary design sketches of the various concepts were made.

The results of the analysis are presented in Table V. Four concepts are compared based on a series of parameters taken from the NASA suggested guidelines. These parameters are weighted as shown for relative importance. Each concept is assigned a graded index for its performance relative to each parameter. While the table is the final guide, an explanation of the parameters and their weights are given in the following paragraphs.

a) Protection of Sensitive Component Areas

This area covers the ability of the filter to protect the internal parts of a component from the type of contamination to which it may be sensitive. The normally sensitive areas in a component are the poppet and seat combination, orifices and sliding surfaces. The contaminant condition may be fibers which tend to lay across a seat area, coarse particulate which can cause erosion or block orifices, or fine particulate which causes silting or "damming" in flow passages and friction and galling between mating surfaces.

On weight scale of 1-5, this characteristic was assigned the maximum importance of 5.

b) Integration of Filter Into Component Passages

This factor is concerned with the ease of adaptation of a filter concept into the flow passages of a typical

Concept / Parameter	DYNALLOY Characteristic	In	Wt	WIRE MESH Characteristic	In	Wt	LAMINATED MESH Characteristic	In	Wt	COLLIMATED HOLE STRUCTURE (CHS) Characteristic	In	Wt	COMBINATION DYNALLOY & CHS Characteristic	In	Wt
Compatibility with 100% Oxygen at 8000 to 10,000 PSI	Totally compatible. Welded all stainless construction.	5	1	Total compatible. Welded all stainless construction.	5	1	Totally compatible. Welded all stainless construction.	5	1	Totally compatible. Welded all stainless construction.	5	1	Totally compatible. Welded all stainless construction.	5	1
Temperature Environment, Storage, Transportation and Operating.	Totally Compatible	5	1	Totally Compatible	5	1	Totally Compatible	5	1	Totally Compatible.	5	1	Totally Compatible	5	1
Static Pressure Environment	Totally compatible.	5	1	Totally Compatible.	5	1	Totally compatible.	5	1	Totally Compatible	5	1	Totally Compatible	5	1
Impact Shock 19.5 g saw tooth 11 ms Rise Time	Totally Compatible.	5	1	Totally Compatible.	5	1	Totally Compatible.	5	1	Totally Compatible	5	1	Totally Compatible	5	1
Random Vibration 20 to 2000 Hz 2 hrs duration	Totally Compatible.	5	1	Totally Compatible.	5	1	Totally Compatible.	5	1	Totally Compatible	5	1	Totally Compatible	5	1
Proof Pressure 12,000 PSI 5 min.	Will not fail, however some deformation to match back up screen and holes in perforated plate is possible	3	2	Deformation to match holes in perforated is possible. If pleating req'd, pleats will collapse	2	2	Totally Compatible.	5	2	Totally Compatible	5	1	Totally Compatible	5	1
Burst Pressure 16,000 PSI	Same comment as above	3	2	Same comments as above	2	2	Totally Compatible.	5	2	Totally Compatible	5	2	Totally Compatible	5	2
Fastening	Welded or mechanical lock internal to valve	5	2	Welded or mechanical lock internal to valve	5	2	Welded into valve	4	2	Welded or mechanical lock internal to valve	5	2	Welded or mechanical lock internal to valve	5	2
Weight	.0014 lbs. calculated	4	2	.0019 lbs. calculated	2	2	.0021 lbs. calculated	1	2	.001 lbs calculated	5	2	.002 lbs. calculated	2	2
Reliability	Good, some potential life limitation	3	3	Good for flat design Poor for pleated version.	2	3	Excellent, reference to structural capacity. Potential life limitation.	2	3	Excellent structurally and for potential life.	4	3	Good, some minor life limitation	3	3
Maintenance	Removal and replacement is simple.	5	2	Removal and replacement is simple.	5	2	Removal and replacement is simple.	5	2	Removal and replacement is simple.	5	2	Removal and replacement is simple.	5	2
Development Risk	None	5	2	None	5	2	None	5	2	None	5	2	None	5	2
Envelope	Disc design will adapt easily to valve passages and ports. No minimum diameter limitation.	5	2	Disc design will adapt easily to valve passages and ports. Diameter limitation with pleats.	5	2	Disc design will adapt easily to valve passages and ports. No minimum diameter limitation.	5	2	Disc design will adapt easily to valve passages and ports. Minimum diameter 0.150"	4	2	Disc design will adapt easily to valve passages and ports. Minimum diameter 0.150".	4	2
Cost - Filter System (1 piece)	$50.00	5	2	$90.00 Flat, $160.00 pleated	5	2	$500.00	1	2	$150.00(4 unit plate)	3	2	$250.00	2	2
Cost - Installation (In valve passage)	$95.00	4	3	$95.00 Flat, $110.00 Pleated	4	3	$75.00	5	3	$75.00	5	3	$75.00	5	3

TABLE V
HPOF CONCEPT STUDY MATRIX
MINOR COMPARATIVE PARAMETERS

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BRUNSWICK

Parameter \ Concept	Dynalloy Characteristic	In	Wt	Wire Mesh Characteristic	In	Wt	Laminated Mesh Characteristic	In	Wt	Collimated Hole Structure (CHS) Characteristic	In	Wt	Combination Dynalloy & CHS Characteristic	In	Wt
Protection of Sensitive Component Areas	Protection Down to 3-4 Micron GBR. protects against silting and abrasion.	4	5	Protection to 10 Micron GBR protects against abrasion.	2	5	Protection to 5 Micron GBR, Protects against silting and abrasion.	3	5	Protection to 3-7 micron GBR. Protects against abrasion.	1	5	Protection Down to 3-4 micron GBR. Protects against silting and abrasion.		
Integration of Filter into component passages	Welded in place, weld to fitting or mechanical lock and seal in place.	5	4	Welded in place, weld to fitting or mechanical lock and seal in place.	5	4	Welded in place or weld to fitting. Mechanical Lock not possible owing to lateral flow potential.	3	4	Welded in place or to fitting or mechanical lock and seal in place.	5	4	Welded in place, weld to fitting or mechanical lock and seal in place.	5	4
Fail Safe Design	Designed to withstand high pressure shock. Supported by screen and perforated plate. Blow through potential only to dia. of perforation.	3	5	Designed to withstand high press. shock. Supported by back up screen and perforated plate. Blow through potential only to dia of perforation. If pleating req'd. pleats may collapse.	2	5	Will withstand shock without deformation. Homogenous construction.	5	5	Will withstand shock without deformation. Homogenous construction.	5	5	Design to withstand high pressure shock. Dynalloy supported by CHS on both sides if necessary.	5	5
Filtration Rating	3-4 Micron GBR. Particle extrusion limited by depth characteristics of Dynalloy.	4	4	10 Micron GBR. Particle extrusion is feasible.	2	5	5 Micron GBR. Pores not necessarily uniform. Dependant on material flow during callendering.	2	5	6 Micron GBR current CHS 3 micron GBR in work. Particle extrusion is possible.	2	5	3 Micron GBR potential. Addition of Dynalloy gives depth filtration capability.	5	5
Cleanliness to Level 25, Table I, JSC-SN-C-005	Some difficulty due to depth characteristic of media and layered nature of design. Difficult to reclean after service.	2	4	Original cleaning not difficult. Recleaning after service may be difficult due to layered nature of design.	3	4	Cleaning difficult due to laminated design with compressed layer at outer surface.	1	4	Capacity for cleaning and recleaning excellent.	5	4	Some difficulty due to depth characteristic of media and layered nature of design. Difficult to reclean after service.	2	4
Life - 100 Cycles or 5 years	Ability to take out fine (silting) contaminants will shorten life, depending on contaminant loading, 100 cycles may be satisfactory.	3	4	10 Micron GBR will permit extended life. 100 cycles should be allowable.	5	4	Limited no. of orifices per square inch reduce life. 100 cycles might be feasible depending on contamination requirements.	1	4	High open area reduces impingement velocity hence bridging rather than plugging of orifices. 100 cycles is satisfactory.	5	4	Staged filtration will increase potential life. 100 cycles life is assured.	5	4
Useful Life	Assume 100 cycles prior to maintenance. Difficulty in recleaning to restore original condition limits to 250 cycles approx.	2	3	100-150 cycles prior to maintenance. Minor difficulties in recleaning will limit life to 500-600 cycles approx.	4	3	50-100 cycles prior to maintenance. Difficulty in recleaning will limit life to 100-200 cycles.	1	3	100-200 cycles prior to maintenance. Life limited only by number of times of possible installation. 1000-2000 cycles possible.	5	3	100-150 cycles prior to maintenance. Difficulty in recleaning to restore original condition limits life to 300-400 cycles approximately.	2	3

TABLE V
HPOF CONCEPT STUDY MATRIX
MAJOR COMPARATIVE PARAMETERS

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valve. It is desirable not to use seals in this installation and to have the unit welded or mechanically locked in place. The most optimum installation will be an all-welded design with use of a burn down flange technique to permit removal and replacement after cleaning. Since TIG welding will be the preferred installation technique, access to the proposed filter location in the valve will be a consideration.

On a weight scale of 1-5, this factor was given a high rating of 4 in view of the overhaul and useful life requirements.

c) Fail Safe Design

Analysis of the disc type filter designs used in valves and regulators indicates that the predominant failure made is a bulging of the filter media culminating in a "blow-through" type hole. This is caused by excessive pressure drop due to contaminant build up or by a pressure differential shock wave from rapid actuation of the shut-off valve. This particular facet of the filter design was the prime motivation for the HPOF program in view of some noted failures in an SOP evaluation test program. This factor was accorded the maximum weight of 5.

d) Filtration Rating

This characteristic is closely related to the initial consideration of protection of sensitive component areas. The stated performance requirements are 10 microns absolute (i.e. largest particle dimension) with a goal of 3 microns absolute. This latter figure can only be approached

by a depth type media with a glass bead rating close to 3 microns. Open pore type medias cannot give this degree of control for the largest dimension, particularly in the case of fibers.

This parameter was also given a weight of 5 on the selected scale.

e) Cleanliness

The required cleanliness is to Level 25, Table I of JSC-SN-C-005 specification. Cleaning to this level is not a difficult process, however, the effectiveness is related to the type of media and the nature of the design. Cleaning of depth media is inherently more difficult than the barrier type media since the pores of the media are not readily exposed to external action of the cleaning solvents.

The standard Wintec cleaning techniques involve the cleaning of the media and mating hardware at each stage of fabrication and assembly. In addition, all of these processes are performed in a class 10,000 clean room which eliminates the bulk of all contaminants normally inherent to the manufacturing process.

Cleanliness is important to the filter and to the component which it is installed in that it should not add contamination to the system during use. It has been given a rating of 4 on our weight scale.

f) Life

The stated requirement in this area is 100 cycles or

5 years. Inasmuch as none of the concept designs are time sensitive, the life is totally dependent upon the number of cycles ot which the filter is exposed. Various characteristics of the media control the effective life. Depth media will have a better overall efficiency over a broad particle size range, hence their life will be more limited than a woven mesh which has a very discreet pore size (i.e., Glass Bead Rating) but allows the bulk of the finer particles to pass through the media. Staged filtration wherein the large particles are removed by the initial layer and fines by the second stage will have the longest initial life.

Initial life in the system is important for an astronaut oxygen system and it has been assigned a weight factor of 4.

g) Useful Life

This characteristic is defined as the maximum possible life which is obtainable from a filter. This is dependent upon two factors, either one of which may be the controlling factor in a particular system. One is the mechanical aspect of the number of times the filter can be removed from the system and re-installed. The other item is the capability of the unit to be re-cleaned to a high percentage of its original condition. Since the initial life is judged to be more important than the reusability potential, this has been assigned a weight of 3 on the scale.

The results of the concept study were reviewed with the Contractor Monitor. Several changes were made in the index and weight ratings. With these changes the results of the study were completed. Based on the results of this study, two concepts were approved for consideration in the concept optimization phase and for preliminary design effort. These are:

a) Dynalloy

b) Combination Dynalloy/CHS

5-2 CONCEPT OPTIMIZATION

This portion of the study resulted in a detailed System Problem Statement which is contained in Appendix D. This problem statement outlines all of the performance requirements and environmental effects for the HPOF.

SECTION 6

DESIGN PHASE

6-1 PRELIMINARY DESIGN

Preliminary design drawings were made for the CHS/Dynalloy combination unit. The drawings were reviewed and approved by the Technical Monitor for creation of the Final Design. The design of the CHS/Dynalloy combination is shown in Figure 10. The Wintec part number is 101-1258.

6-2 FINAL DESIGN

The detail design of the basic HPOF unit was prepared. The CHS/Dynalloy unit P/N 101-1258 (Ref. Figure 10) is EB Welded into a sleeve to facilitate a wide variety of mounting and installation possibilities. The Wintec part number for this final assembly is 9-812. Final assembly drawings for the test tooling and fixtures and the manufacturing tooling were also prepared. During a review visit to JSC White Sands Test Facility, it was agreed that Wintec could both design and fabricate test fixtures for the White Sands Certification Tests in addition to the fixtures and tooling required by Wintec. This enabled schedule requirements to be met.

The Acceptance Test Plan and the Certification Test Plan were completed and are contained in one combined document. A copy of this document, Wintec plan number TP 258, is included as Appendix E to this report.

The materials listing is indicated on each of the appropriate drawings. The bill of material and production

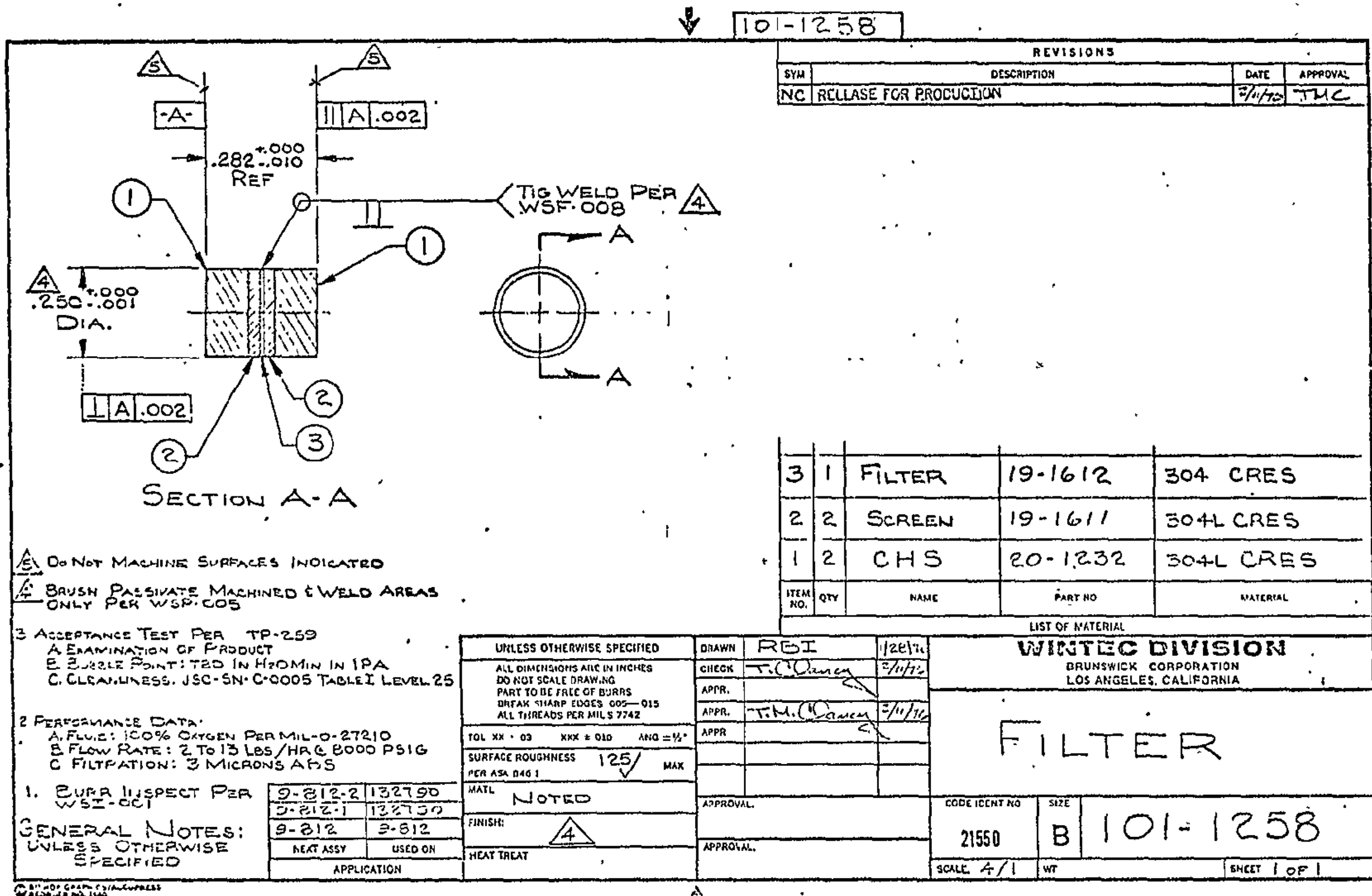

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FIGURE 10

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planning documentation was also prepared.

Much later in the program, following the failure of HPOF S/N 3 under impact testing at NASA WSTF, and urgent redesign program was undertaken on the structural sleeve which houses the filter assembly. The failure consisted of the CHS filter disc being expelled from the sleeve with the failure taking place in the electron beam welded section

A decision was to abandon electon beam welding as the final assembly process. The available solid section at the outside surface of the CHS unit is apparently too thin to permit adequate weld penetration.

An enclosure type fitting was designed which used TIG welding as the final process. This design was released for the manufacture of six test units. Tooling for acceptance testing was redesigned to accomodate the increased HPOF diameter. A plug was designed for the proof loading fixture ti ensure that the load is applied entirely to the CHS filter surface and hence to the weld and the retention lip of the structural sleeve. The redesigned HPOF assembly is shown in Figure 11.

6-3 FINAL DESIGN, FABRICATION AND TEST PLAN PRESENTATION

The complete design package was reviewed with NASA JSC Houston personnel to finalize the approval for fabrication of the HPOF samples for Certification Test. The proposed installation for demonstration purposes in the Airesearch Skylab SOP shutoff valve was also discussed.

The presentation to NASA included a complete briefing of the program from its inception. The fabrication processes,

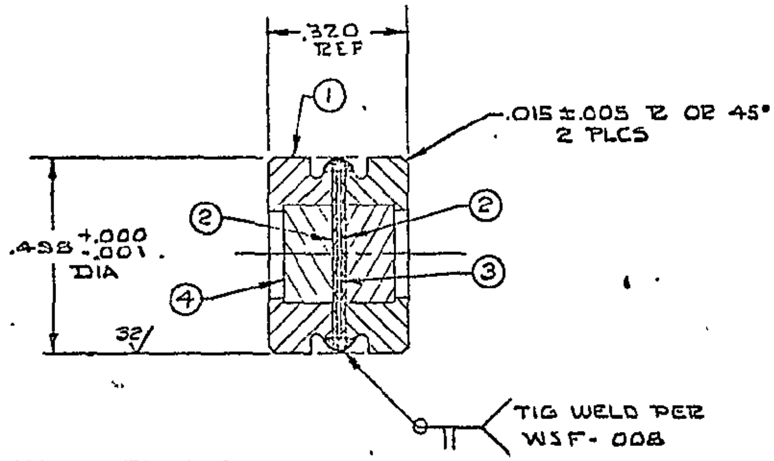
materials and test plans were reviewed and approved.

6-4 TEST TOOLING AND FIXTURE DESIGN

Design of tooling and fixtures for flow-pressure drop, vibration, bubble point and welding were prepared, reviewed by NASA personnel and approved. Designs of the various tools and fixtures are shown in Figures 12 through 15.

9-812

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
D	RE-DESIGNED & RE-DRAWN	[illegible]	[illegible]



GENERAL NOTES. UOS

1. FLUID: 100% OXYGEN PER MIL-O-27210
2. FLOW RATE: 2 TO 13 LBS/HR @ 8000 PSIG
3. FILTRATION: 3 MICRONS ABS
4. ACCEPTANCE TEST PER TP259
5. BURR INSPECT PER WSI-001

ITEM NO	QTY	NAME	PART NO	MATERIAL
4	2	CHS	20-1232	304 CRES
3	1	FILTER	19-1612	304 CRES
2	2	SCREEN	19-1611	304L CRES
1	2	RING	20-1265	304L, 316L, 321 OR 347 CRES

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES DO NOT SCALE DRAWING PART TO BE FREE OF BURRS BREAK SHARP EDGES .005—.015 ALL THREADS PER MIL S 7742	DRAWN	J.D.	6-11-76	WINTEC DIVISION BRUNSWICK CORPORATION LOS ANGELES, CALIFORNIA
TOL XX ± .03 XXX ± .010 ANG ± ½°	CHECK	[illegible]	[illegible]	CHS FILTER
SURFACE ROUGHNESS PER ASA B46.1 125 MAX.	APPR			
MATL —	APPR	[illegible]	[illegible]	
FINISH CLEAN PER WSP-010	APPR			
HEAT TREAT	APPROVAL			CODE IDENT NO. 21550 — SIZE B — 9-812
NEXT ASSY — / USED ON — / APPLICATION	APPROVAL			SCALE 4/1 — WT. — — SHEET 1 OF 1

FIGURE 11

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SECTION 7

FABRICATION PHASE

7-1 FABRICATION OF TEST FILTERS

An order was released to Brunswick in Skokie, Illinois for manufacture of the required quantity of CHS units. These parts were drawn to size but during the leaching process, the bridge work between the holes (approximately 1 micron thick) was attacked by the acid. Metallurgical examination showed this to be due to sensitization of the matrix during an imperfect annealing process.

A second CHS bar was drawn to size, cut into 1/8" thick slices and leached for 88 hours in nitric acid. The CHS were leached completely through by this process, however, later inconsistencies in flow-pressure drop data confirmed the belief that varying amounts of core material remained in the CHS capillaries.

All of the CHS slices were bubble pointed, selected in pairs and TIG welded into a sandwich using 3 micron Dynalloy and two 80 mesh "flow distribution" layers. The outside was lightly "dry" machined to create the filter part no. 101-1258. Following cleaning, this unit was pressed into a sleeve and electron beam welded to create the final filter assembly, part no. 9-812. The first four of these units had an electron bead penetration of .008 to .010". This penetration later proved to be insufficient since one of the units "blew out" of its sleeve during proof test.

Microscopic examination of the surface of the CHS showed

surface attack by the leaching acid, however this condition was at the surface only and would not inhibit the filtration characteristics of the CHS. This surface attack did permit the surface material of the hole "lattice" to fold over during the Acceptance Proof Test. This was confirmed by a series of increasing magnification photographs taken on the back-scatter electron microprobe at NASA WSTF. The key photographs are shown in Figures 16 and 17.

Following the proof test failure, four HPOF unis were assembled using a deeper electron beam weld penetration. This change proved to be unsatisfactory since the additional shrinkage due to the increased weld depth cracked the surface of the collimated hole structure.

The proposed solution to the problem was to machine a burn-down flange on the inside of the holding sleeve. This permitted the shrinkage forces to act on thin burn-down lip instead of the body of the CHS element. Existing sleeves were reworked and six new units were manufactured.

Upon examination of the first two units it was found that the electron beam weld penetration was insufficient. This was an error on the part of the electron beam welder. The balance of four units were re-welded and weld penetration was satisfactory at .025 min.

An addition bar of CHS material was drawn down for cutting into filter slices. These slices were "pressure-pulse" leached at the Brunswick Sherwood "Monoject" division in Connecticut. This particular leaching process is used

for rapid removal of core material from hypodermic needles. The acid used in this process is more concentrated than that used in static leaching but the exposure time will be significantly less. It was anticipated that this would relieve the surface etching problem.

A set of six units were manufactured using the pulse leached CHS slices. The electron beam welding on these units was marginal. Some surface cracks in the CHS matrix were visible. The holding sleeves were modified to have a much thinner burn-down flange (.010). Three of these units were submitted to the test department for review. Slight surface cracks were still evident.

At this stage of the program, HPOF Serial No. 3 was expelled from its sleeve during the cyclic impact test program at NASA WSTF. This failure prompted a major redesign sequence in in the program, as described in Section 6.

Four filters of this new design configuration were manufactured without difficulty. Welding of the new design was all TIG and since the CHS portion of the filter was not involved in the welding, there was no problem of shrinkage cracks or occlusion of the CHS. The only unusual manufacturing requirement was a higher-than-normal Argon purge pressure requirement owing to the inherent high pressure drop of the CHS under flow conditions.

7-2 FABRICATION OF TEST TOOLING

All of the test tooling was fabricated and either held at Wintec or shipped to NASA White Sands for use in the Certi-

fication Test Sequence. The quantity, part no., and description of test tooling is shown in Table VI. In addition to this list, an extra Bubble Point Test Fixture was manufactured for use at Wintec.

Problems with galled test fixtures occurred at NASA WSTF. The bubble test fixture was one of the galled units. It was forced apart and lack of lubrication was discovered at the apparent problem. This unit was modified by NASA to be a bolted design, thus eliminating the need for threads.

A galled flow fixture was returned to Wintec. After separation a larger thread size was machined into the body and a new mating fitting was manufactured. A baked on lubricant, "Dicronite", was added to the threads and the unit was returned to NASA WSTF under the part number 4-2503-20 to distinguish this fixture from the standard 4-2503 in existence with smaller threads.

TABLE VI

TOOLS AND FIXTURES

Description	Part No.	Qty	Location
Flow & Proof	4-2503	2	White Sands
Vibration	4-2500	1	White Sands
Flow & Proof	4-2498	1	Wintec
Bubble Point (9-812)	4-2499	1	White Sands
Bubble Point (101-1258)	4-2504	1	White Sands
EB Weld Holder	4-2501-1	1	Wintec
EB Weld Holder	4-2501-2	1	Wintec

FIGURE 12

FLOW & PROOF

P/N 4-2498

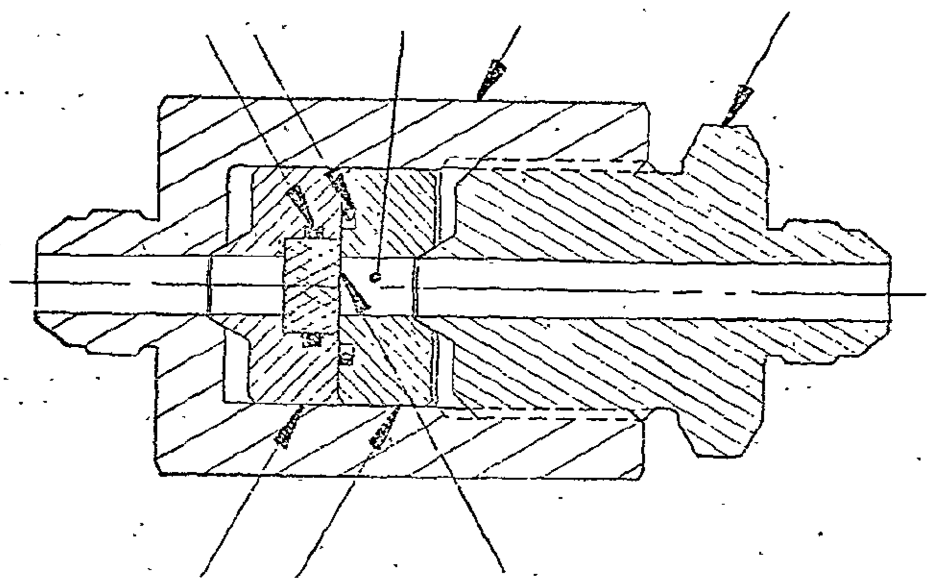
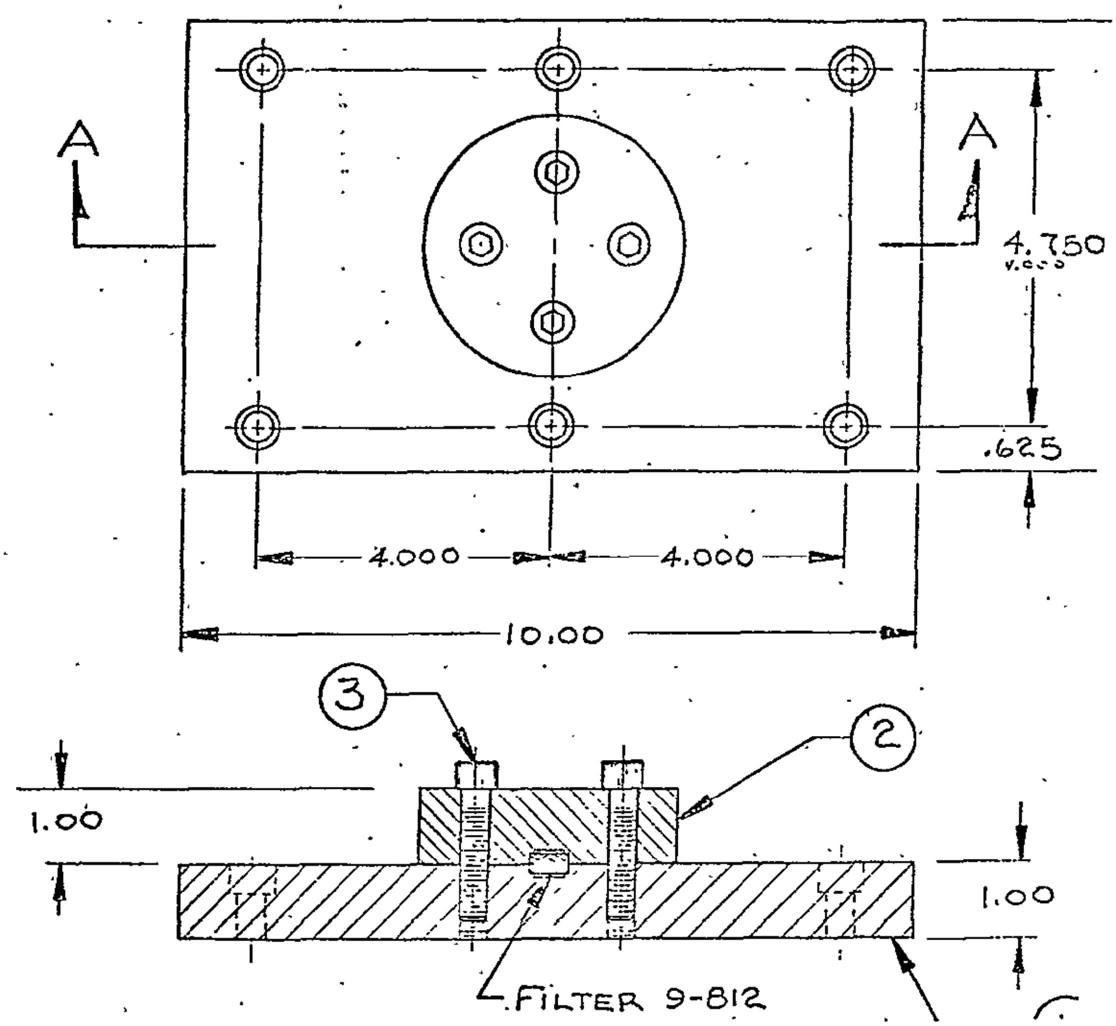


FIGURE 13

VIBRATION

P/N 4-2500



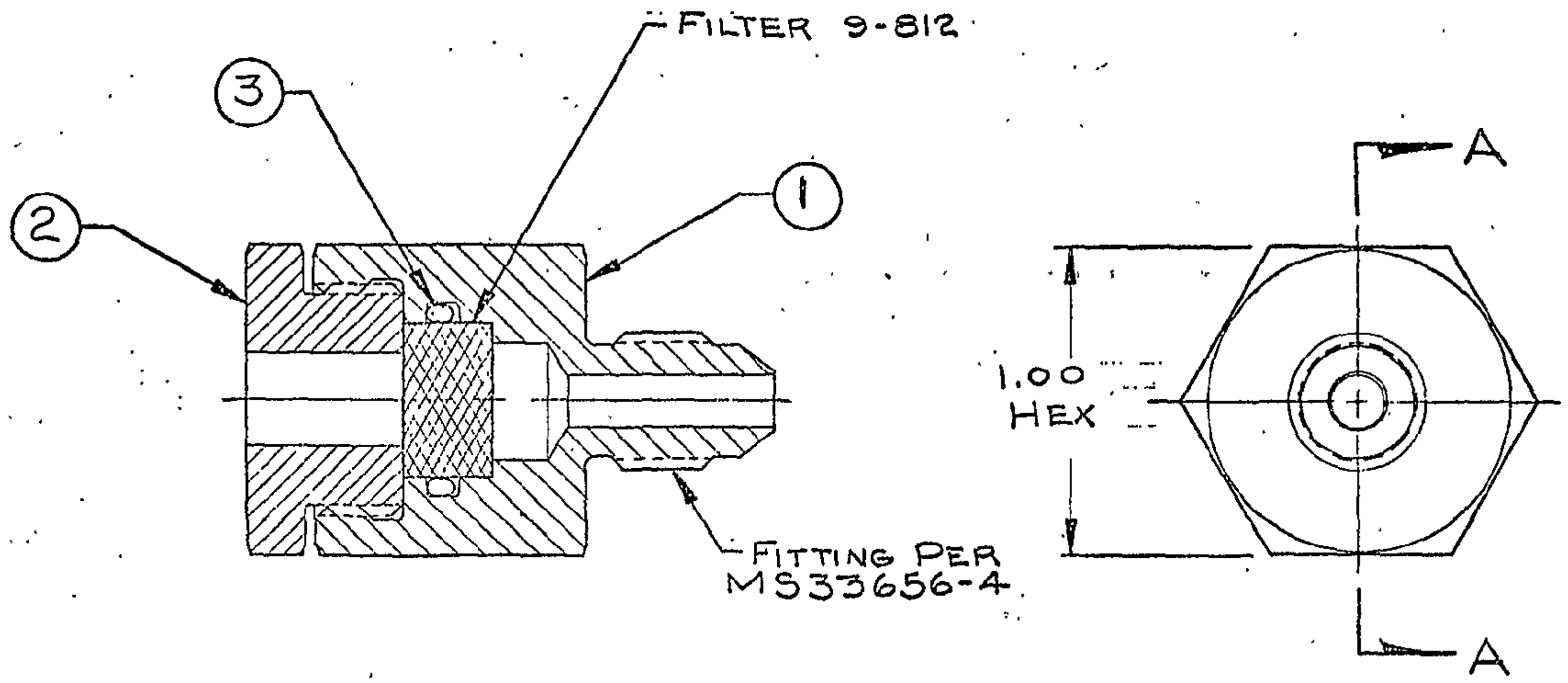


FIGURE 14

BUBBLE POINT

P/N 4-2499

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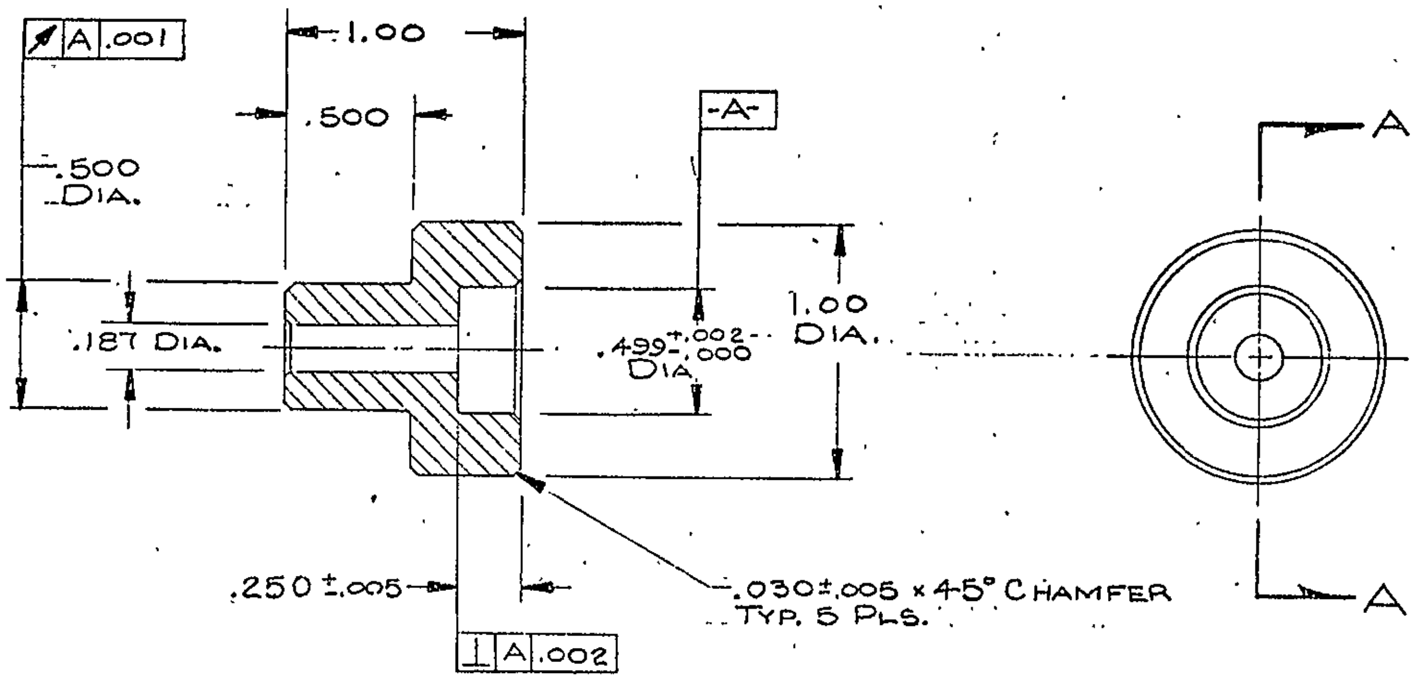

FIGURE 15

EB WELD HOLDER

P/N 4-2501-1

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FIGURE 16

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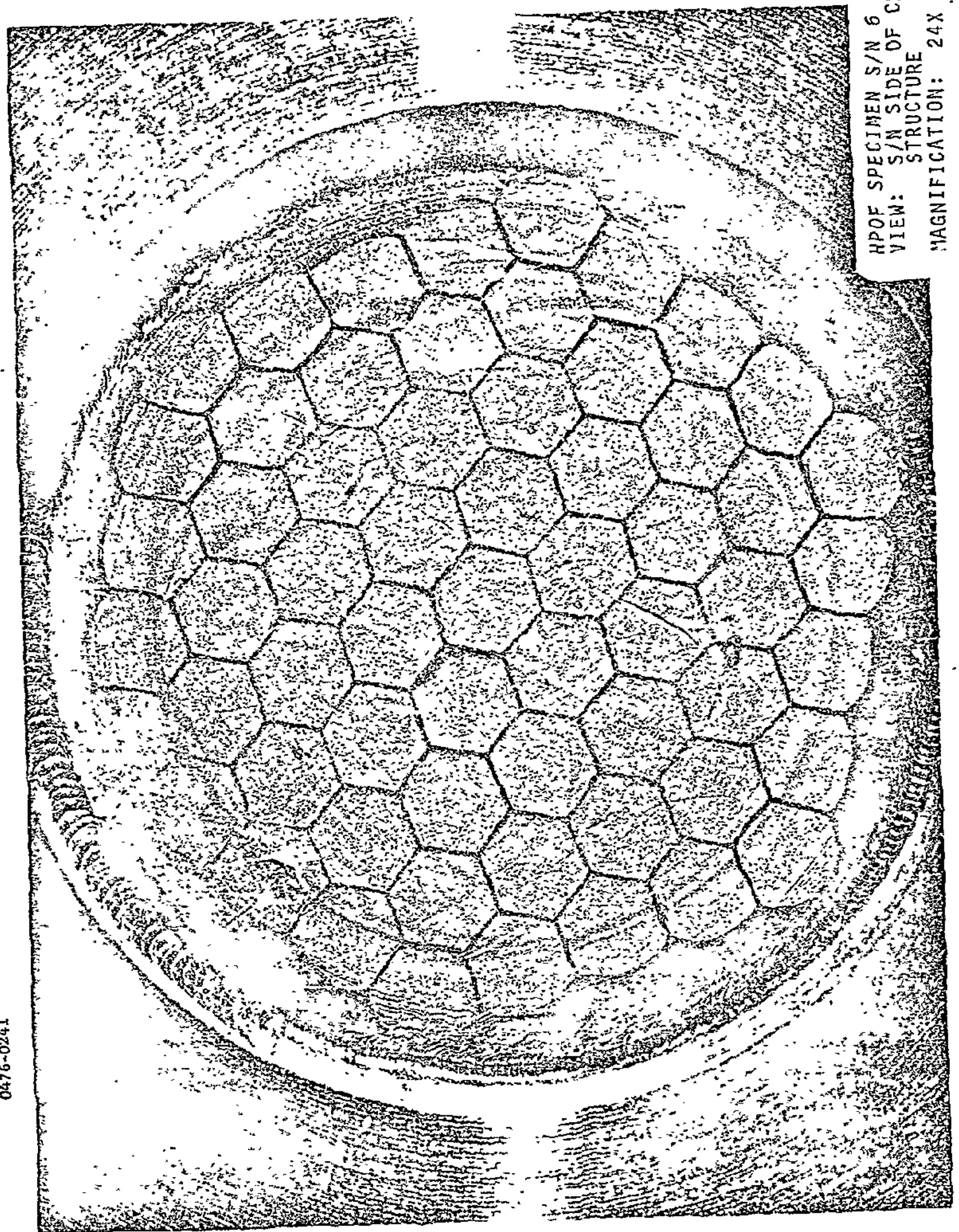

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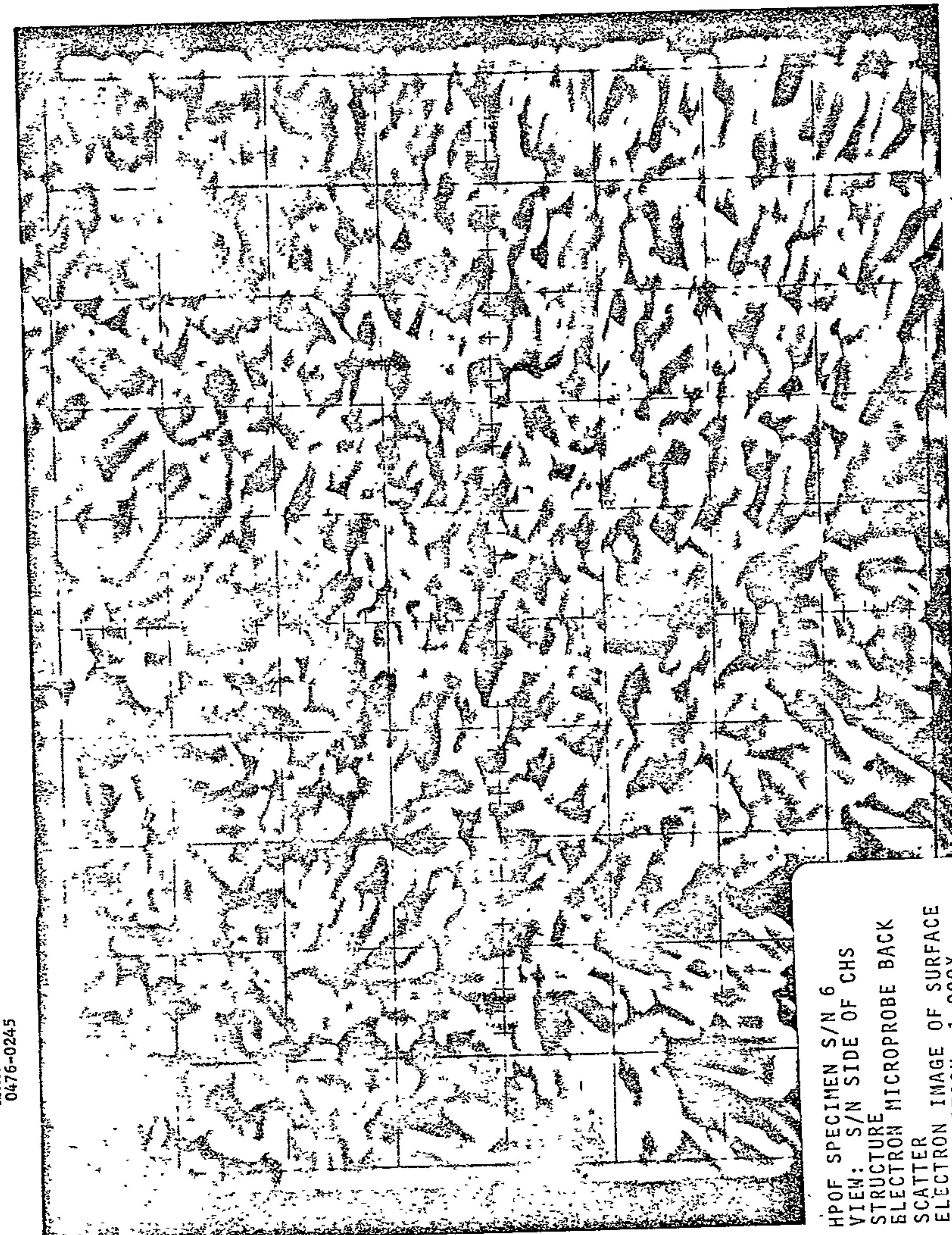
FIGURE 17



NASA WSTF
0476-0245

HPOF SPECIMEN S/N 6
VIEW: S/N SIDE OF CHS
STRUCTURE
ELECTRON MICROPROBE BACK
SCATTER
ELECTRON IMAGE OF SURFACE
MAGNIFICATION: 1,000X

SECTION 8

TEST PHASE

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8-1 ACCEPTANCE TEST PROCEDURE

A comprehensive procedure was written for the Acceptance Test phase of the program. This procedure was approved and released as Wintec document no. TP 259. Several revisions were required during the design and test phases of the program to accomodate the changes in design as a result of the test findings. This procedure differs from normal filter test procedures owing to the unusual bubble point and flow test methods occasioned by the use of the CHS discs as a part of the sandwich design. TP 259 is included as Appendix F.

8-2 Acceptance Tests

Bubble point tests were run on all of the CHS slices as a part of receiving inspection. These tests indicated the surface corrosion and random incomplete leaching of the CHS slices of the initial group.

The first group were not usable, and, following changes in the leaching process, an additional group of CHS slices were processed by Brunswick. These had been pulse-leached in the Brunswick Sherwood facility in Connecticut.

Bubble point tests were run on this latter group of fifty-two (52) pulsed leached CHS slices. The discs were numbered and the recorded data is shown in Table VII.

Following welding into final configuration the filters, part number 9-812, were subjected to additional bubble point and flow-pressure drop tests. Bubble point results are

shown in Table VIII with flow-pressure drop results in Table IX. A plot of typical flow-pressure drop data for a single unit is shown in Figure 18.

The pressure drop results were inconsistent and high. These data were given to NASA WSTF who transmitted the data to NASA JSC Houston. Tentative approval was given to the magnitude of the pressure drop. A Failure Analysis Report was written for the high flow pressure drop condition. This was published as Wintec Report TR 359 and is included as Appendix G to this report.

This report discussed the high clean flow-differential pressure (ΔP) experienced with HPOF's S/N's 002, 005 and 006. Due to flow limitations of the HPOF it was necessary to increase the inlet pressure from 3.52 Kg per sq. cm. (35.3 psig) to 29.2 Kg per sq. cm. (400 psig). The Acceptance Test Procedure TP 259 was revised to permit testing at the new increased inlet pressure.

In addition, a single unit failed on the proof test. A Failure Analysis Report (TR 355) was written for this condition also. The method of application of proof load was by means of a thin foil on the surface of the unit. It was felt that the use of the thin foil has caused the surface to lattice to "fold over". A change to a different thickness and style of pressure restraint for the proof tests was successful in eliminating this problem.

Following the design change to incorporate a burn-down flange in the retaining sleeve, four units of the revised design were subjected to Acceptance Testing. Bubble Point

results for these units are shown in Table X and Flow-Pressure drop results are in Table XI.

The NASA Test Directive (TD121-025) was revised to reflect changes in test sequence and revised test system schematic. System pressures were also changed to compensate for increased pressure drops at rated flow.

Following the impact cycle failure referred to in Section 6 of this report, a major design change was occasioned to the filter retaining sleeve.

Three HPOF assemblies of the revised configuration were subjected to acceptance test requirements and subsequently shipped to NASA WSTF for testing under dynamic conditions. The parts of the revised configuration are joined together by fusion (TIG) welding of the two outer rings to each other at the axial center of the filter assembly. Serial numbers of the initial units of this configuration were 022, 023 and 024.

Following successful cyclic impact testing by NASA of this design, five additional HPOF assemblies were subjected to acceptance tests at Wintec and shipped to NASA WSTF. The units were shipped in two separate lots. Lot #1 consisted of S/N's 021 and 025. Lot #2 consisted of S/N's 027, 028 and 029.

8-3 CERTIFICATION TEST PROCEDURE

Early in the preparation phase of this document, it became obvious that the procedure could not be prepared without a significant amount of NASA WSTF participation and advice.

Since all of the certification testing was to be performed at WSTF, the available equipment and NASA test methods and philosophy dictated the content of the Wintec procedure. Publication of this procedure was delayed until the NASA Test Directive TD-121-025 was published. Wintec supplied information and assisted in the preparation of this document which is included in this report as Appendix H. Following this publication, the Wintec Certification Test Procedure TP 260 was issued and submitted to NASA for approval. The procedure was basically petterned after the NASA test directive but all of the system operation details were eliminated. A copy of the approved Certification Test Procedure is included as Appendix I to this report.

8-4 DESIGN CERTIFICATION TEST

Test system build up was performed at NASA JSC White Sands Test Facility under the direction of Fred Sabottka of Lockheed Electronics, the Site Support Contractor at White Sands. Proof test for his facility was completed in March 1976 and verified the operational capability of the system.

The charge amplifiers loaned to Wintec by NASA WSTF for the Transient Pressure tests on the SOP and OPS systems were returned to White Sands for use in the Certification Test Program. The Kistler Transducers and associated mounting hardware used in the transient pressure tests were also shipped to WSTF for use in the Certification Test Program.

After review of the Wintec Acceptance test data and

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TABLE VII

CHS DISC BUBBLE POINT DATA

UNIT S/N	PAIR No.	1st BP in H_2O	2nd BP in H_2O	3rd BP in H_2O	BOIL in H_2O
1	1	37.5	39.0	39.50	55.74
2	1	38.75	39.9	40.0	55.20
3	2	35.4	36.8	37.8	55.74
4	2	34.3	37.8	40.2	55.74
5	3	38.0	38.3	39.5	55.74
6	3	35.3	35.9	38.9	55.74
7		36.1	44.7	44.9	62.54
8	4	36.1	38.5	38.7	55.74
9	4	37.8	37.9	38.0	54.38
10	5	35.3	37.8	38.7	55.74
11		32.7	35.0	38.6	55.20
12	16	35.5	38.3	39.4	55.74
13		33.0	38.7	39.4	55.74
14	14	34.7	37.6	39.0	55.20
15	5	36.0	37.7	38.3	54.38
16		33.5	38.0	39.2	55.74
17	14	34.6	39.1	40.3	55.20
18		33.7	38.3	41.1	55.74
19	6	38.0	38.2	40.8	55.20
20	6	35.6	39.0	39.5	54.38
21	16	32.8	37.2	38.8	53.70
22	7	35.3	37.6	38.9	54.38
23		30.75	38.5	40.3	54.38
24	13	34.4	38.3	38.7	55.74
25	13	34.5	36.7	38.3	53.70
26		32.0	36.5	38.6	55.74
27	7	36.5	36.6	40.0	57.10
28		32.0	39.3	39.5	55.74
29		32.3	39.7	40.1	54.38
30		31.7	38.3	39.7	54.38
31	12	34.0	35.2	39.6	54.38
32	8	36.2	38.5	40.3	56.42
33		33.7	33.8	39.3	54.38
34	8	36.9	37.5	39.4	56.42
35	9	36.3	36.5	39.0	56.08
36		33.5	38.5	40.7	54.38
37	11	34.3	37.3	41.5	55.74
38	11	34.3	35.7	41.7	56.42
39	9	35.5	36.7	39.0	54.38
40	10	36.2	37.7	37.8	56.15
41	10	35.7	38.0	39.8	55.74
42		38.0	38.7	39.7	55.20
43	15	35.0	37.2	39.8	54.38
44		33.6	37.8	39.0	--
45	15	36.1	36.6	38.5	55.20

Units 46 through 52 not used.

TABLE VIII

BUBBLE POINT TEST DATA

S/N	101-1258 (1) IPB " H_2O	9-812 (2) IBP " H_2O	Increased IBP " H_2O	Approx. Decrease in Microns (3)
002	62.883	65.44	2.557	0.029
003	61.590	67.12	5.53	0.276
006	62.887	71.38	8.493	0.383

(1) Filter

(2) CHS Filter with Ring welded in place and after Proof Test.

(3) Decrease in the size of passages in microns using 207 as a bubble point - micron rating conversion factor.

TABLE IX

FLOW PRESSURE DROP TEST DATA

S/N	ΔP (PSID) @ 1.0 SCFM	ΔP (PSID) @ 2.04 SCFM	ΔP (PSID) @ 3.06 SCFM	Inlet Pressure PSIG
002	32	78	138	400
002	47	112	230	300
003	44	115	210	400
003	62	162	-	300
006	37	88	158	400
006	53	132	-	300

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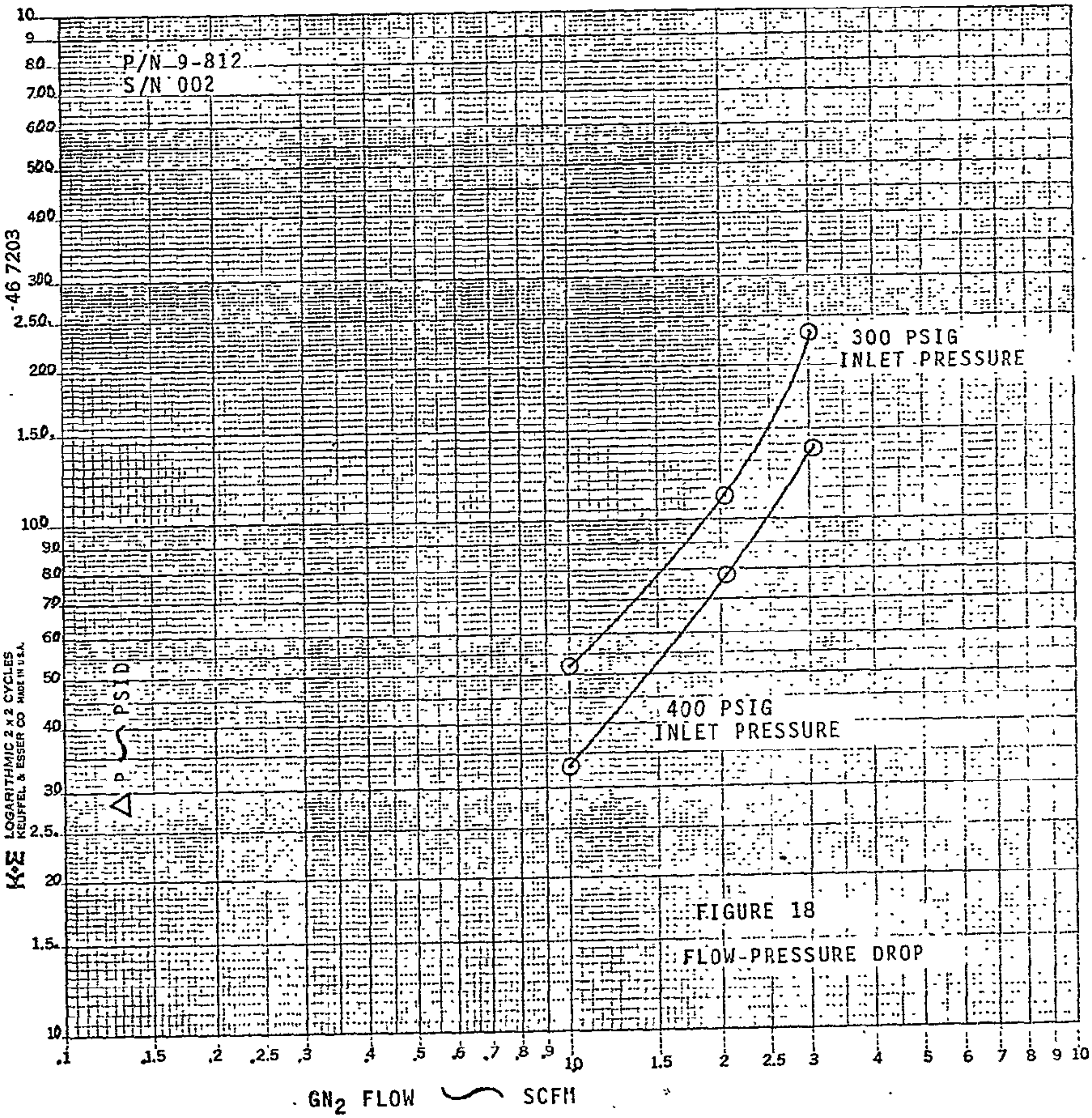

TABLE X

BUBBLE POINT TEST RESULTS

Serial Number	Bubble Point (in. H_2O)
002	70.876
003	72.713
006	77.350

TABLE XI

FLOW-PRESSURE DROP RESULTS

Serial No.	Inlet Press. PSIG	Press. Drop (PSIG) 1.0 SCFM	Press. Drop (PSIG) 2.04 SCFM	Press. Drop (PSIG) 3.06 SCFM
002	400	32	78	138
002	300	47	112	230
003	400	44	115	210
003	300	62	162	--
006	400	37	88	158
006	300	53	132	--

consultation with NASA JSC concerning the high pressure drop characteristic of the HPOF, the lower system tare tests wer eliminated. The test directive TD-121-025 was revised to reflect this.

The test program commenced with the performance of a series of clean condition-flow rate versus differential pressure tests. HPOF test specimen S/N 6 was used for this series. The data from the tests are shown in Tables XII through XIV and graphically shown in Figure 19 through 21. The test specimen inlet pressures were 417.5, 688.7, 998.2 and 2887.6 PSIA. Other parametric values are shown in the noted tables.

The HPOF unit S/N 3 was subjected to a series of flow tests including pre-impact clean flow-differential pressure (ΔP) tests, impact flow-differential pressure tests, and post impact flow-differential pressure tests. The first of this series, the pre-impact clean flow-differential pressure test, using gaseous nitrogen as a test fluid was conducted at 416 and 1,000 psia inlet pressures. The data from the tests are shown in Tables XV through XVIII and graphically shown in Figures 22 - 25.

Upon completion of the clean flow-differential pressure test the HPOF was subjected to GN_2 impact tests. The unit failed during the fourteenth (14th) impact cycle. The 101-1258 filter was expelled from 20-1237 ring. Testing stopped and a failure analysis was commenced.

A Failure Analysis Report TR 121-025 was issued by NASA

TABLE XII
HPOF TEST SPECIMEN S/N 6
CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

Flow Rate (SCFM)	NET DIFFERENTIAL PRESSURE (PSID)			
	TEST SPECIMEN INLET PRESSURE (PSIA)			
	417.5[A]	688.7[B]	998.2[C]	2887.6[D]
0.4	16.319	8.830	6.539	2.958
0.5	21.059	11.033	8.170	3.695
0.6	25.516	13.292	9.835	4.443
0.7	29.875	15.604	11.534	5.204
0.8	34.253	17.969	13.266	5.976
0.9	38.722	20.385	15.030	6.759
1.0	43.330	22.850	16.826	7.553
1.1	48.109	25.363	18.652	8.358
1.2	53.079	27.923	20.507	9.173
1.3	58.252	30.529	22.391	9.999
1.4	63.639	33.179	24.302	10.833
1.5	69.245	35.872	26.241	11.678
1.6	75.072	38.608	28.206	12.531
1.7	81.123	41.386	30.197	13.393
1.8	87.396	44.205	32.213	14.264
1.9	93.892	47.063	34.254	15.144
2.0	100.607	49.961	36.319	16.032
2.1	107.538	52.897	38.409	16.928
2.2	114.682	55.872	40.521	17.832
2.3	122.035	58.883	42.657	18.744
2.4	129.590	61.932	44.815	19.663
2.5	137.344	65.017	46.995	20.590
2.6	145.291	68.137	49.197	21.525
2.7	153.423	71.293	51.421	22.467
2.8	161.735	74.483	53.666	23.416
2.9	170.219	77.708	55.932	24.372
3.0	178.870	80.966	58.219	25.335
3.1	187.679	84.258	60.526	26.305
3.2	196.639	87.583	62.853	27.281
3.3	205.742	90.941	65.200	28.264
3.4	214.981	94.332	67.567	29.254
3.5	224.347	97.754	69.953	30.250

TABLE XII (Cont.)

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (differential pressure)} = a + b\,(\text{SCFM}) + c\,(\text{SCFM})^2 + d\,(\text{SCFM})^3 + e\,(\text{SCFM})^4$$

A. $\text{Log (differential pressure)} = 1.636793 + 1.082282\,(\text{SCFM}) + 0.351928\,(\text{SCFM})^2 + 0.505787\,(\text{SCFM})^3 - 0.688616\,(\text{SCFM})^4$

Sigma = 0.868

B. $\text{Log (differential pressure)} = 1.35888 + 1.089462\,(\text{SCFM}) + 0.130107\,(\text{SCFM})^2$

Sigma = 0.534

C. $\text{Log (differential pressure)} = 1.225979 + 1.076184\,(\text{SCFM}) + 0.11252\,(\text{SCFM})^2$

Sigma = 0.358

D. $\text{Log (differential pressure)} = 0.878142 + 1.058704\,(\text{SCFM}) + 0.089802\,(\text{SCFM})^2$

Sigma = 0.227

TABLE XIII

HPOF TEST SPECIMEN S/N 6

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE (lbs GN_2/hour)	TEST SPECIMEN INLET PRESSURE (PSIA)			
	417.5^A	688.7^B	988.2^C	2887.6^D
1.0	8.585	4.546	3.415	1.586
1.5	13.934	7.141	5.331	2.450
2.0	19.109	9.838	7.312	3.336
3.0	29.331	15.453	11.413	5.153
4.0	39.842	21.289	15.654	7.015
5.0	50.977	27.295	20.001	8.912
6.0	62.940	33.440	24.435	10.836
7.0	75.881	39.703	28.942	12.783
8.0	89.921	46.069	33.513	14.752
9.0	105.165	52.526	38.141	16.737
10.0	121.714	59.065	42.820	18.739
11.0	139.665	65.680	47.545	20.756
12.0	159.116	72.363	52.312	22.786
13.0	180.162	79.110	57.119	24.828
14.0	202.905	85.916	61.962	26.882
15.0	227.445	92.778	66.839	28.946

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (differential pressure)} = a + b\,(\log \text{lbs } GN_2/hr) + c\,(\log \text{lbs } GN_2/hr)^2 + d\,(\log \text{lbs } GN_2/hr)^3$$

A. $\text{Log (differential pressure)} = 0.933734 + 1.271200\,(\log \text{lbs } GN_2/hr) - 0.503528\,(\log \text{lbs } GN_2/hr)^2 + 0.383935\,(\log \text{lbs } GN_2/hr)^3$
Sigma = 0.719

B. $\text{Log (differential pressure)} = 0.657646 + 1.113687\,(\log \text{lbs } GN_2/hr)$
Sigma = 0.873

C. $\text{Log (differential pressure)} = 0.533439 + 1.098208\,(\log \text{lbs } GN_2/hr)$
Sigma = 0.661

D. $\text{Log (differential pressure)} = 0.200419 + 1.072338\,(\log \text{lbs } GN_2/hr)$
Sigma = 0.371

TABLE XIV

HPOF TEST SPECIMEN S/N 6

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE (Kg/hr)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential) TEST SPECIMEN INLET PRESSURE (Kg/sq cm)			
	29.350[A]	48.423[B]	70.188[C]	203.019[D]
0.5	0.792	0.401	0.297	0.134
1.0	1.478	0.788	0.584	0.264
1.5	2.247	1.199	0.886	0.399
2.0	3.098	1.634	1.203	0.540
2.5	4.029	2.091	1.534	0.685
3.0	5.040	2.567	1.877	0.835
3.5	6.127	3.063	2.233	0.989
4.0	7.292	3.578	2.600	1.147
4.5	8.531	4.109	2.977	1.308
5.0	9.845	4.657	3.365	1.473
5.5	11.234	5.222	3.762	1.642
6.0	12.696	5.801	4.169	1.813

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log } (Kg/cm^2 \text{ differential}) = a + b\,(Kg/hr) + c\,(Kg/hr)^2$$

A. $\text{Log } (Kg/cm^2 \text{ differential}) = 0.169613 + 0.984020\,(Kg/hr) + 0.278001\,(Kg/hr)^2$
Sigma = 0.295

B. $\text{Log } (Kg/cm^2 \text{ differential}) = -0.103531 + 1.013419\,(Kg/hr) + 0.129599\,(Kg/hr)^2$
Sigma = 0.142

C. $\text{Log } (Kg/cm^2 \text{ differential}) = -0.233801 + 1.009695\,(Kg/hr) + 0.112600\,(Kg/hr)^2$
Sigma = 0.095

D. $\text{Log } (Kg/cm^2 \text{ differential}) = -0.578458 + 1.005324\,(Kg/hr) + 0.090221\,(Kg/hr)^2$
Sigma = 0.060

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HPOF PROGRAM TEST NO.5

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 6

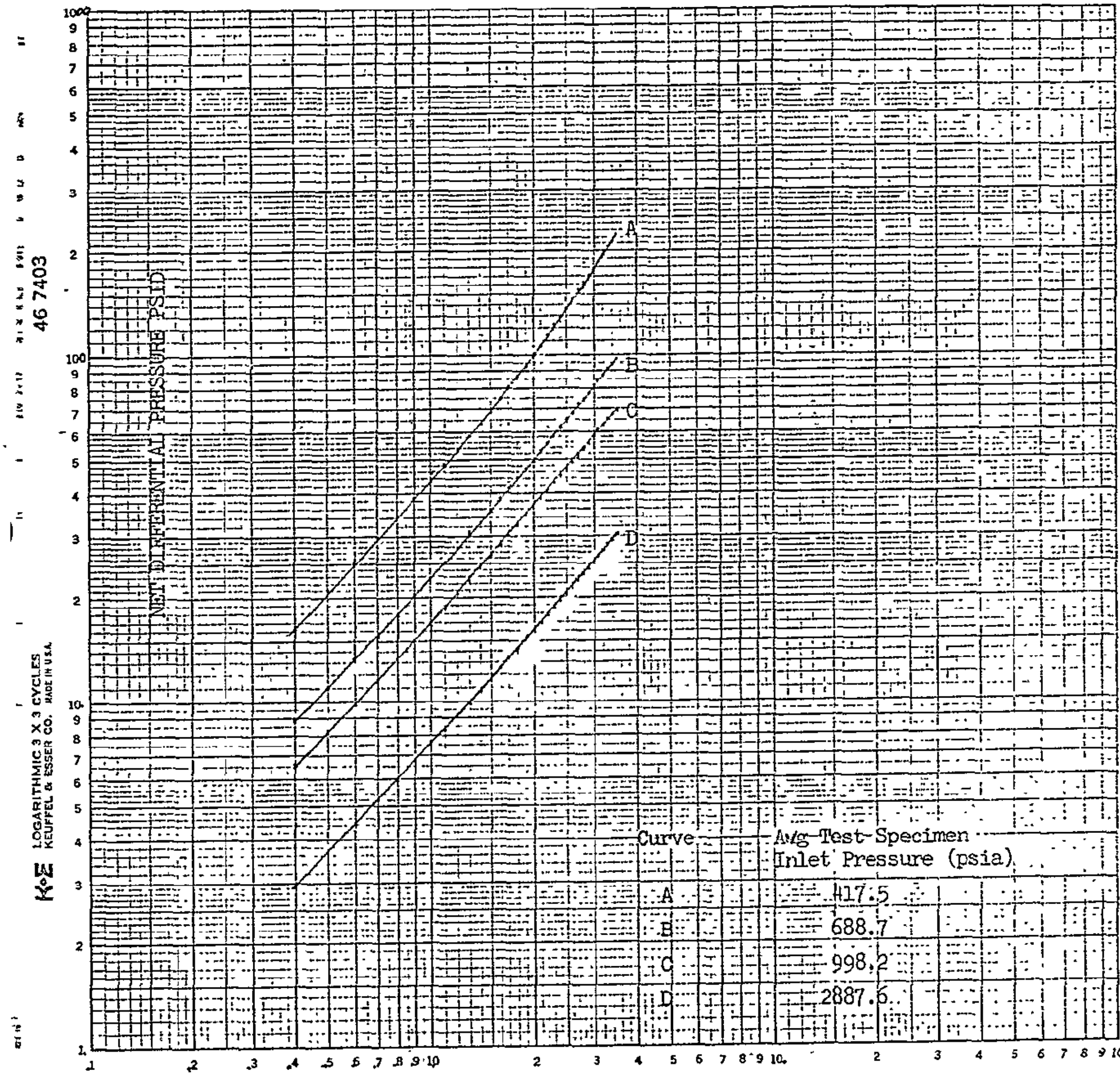
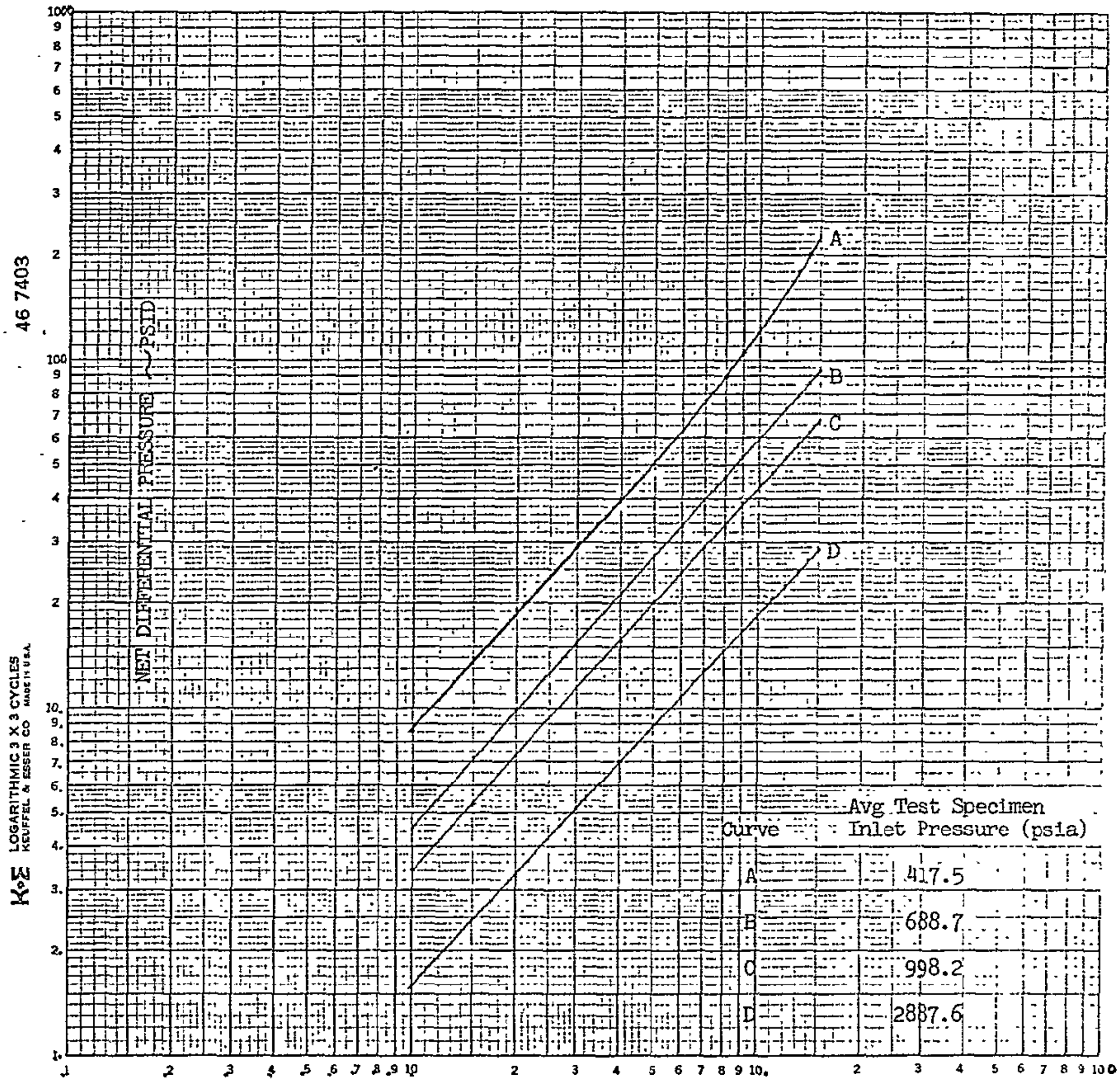


FIGURE 19

HPOF PROGRAM TEST No. 5

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 6



GN$_2$ FLOW RATE ~ POUNDS PER HOUR

FIGURE 20

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HPOF PROGRAM TEST No. 5

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 6

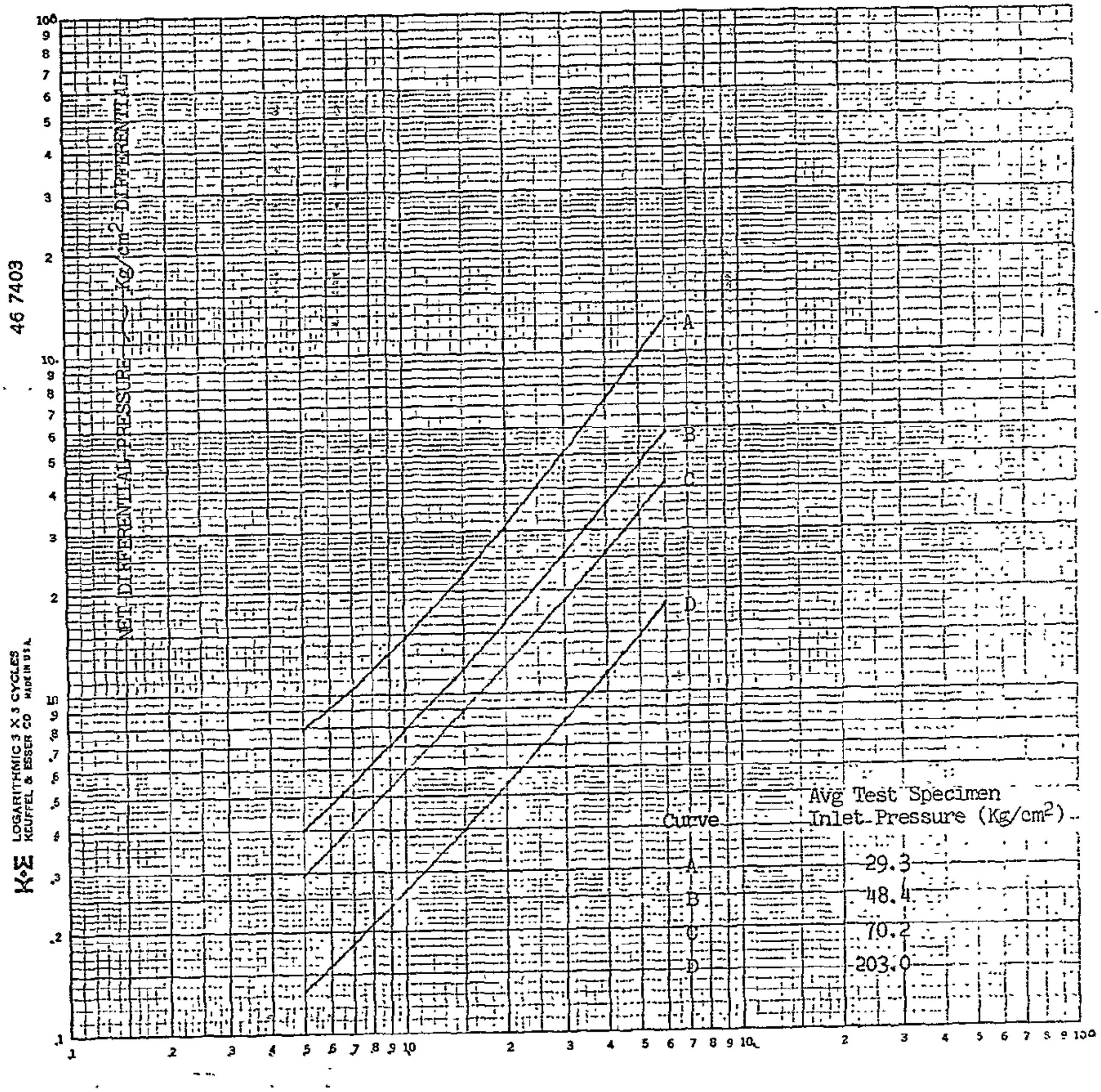

FIGURE 21

TABLE XV

HPOF TEST NO. 6

TEST SPECIMEN S/N 3*

CLEAN CONDITION - PRE GN_2 IMPACT FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE (SCFM)	NET DIFFERENTIAL PRESSURE (PSID) TEST SPECIMEN INLET PRESSURE (PSIA)	
	412.6[A]	1006.8[B]
0.4	13.079	6.858
0.5	22.591	8.803
0.6	27.585	10.796
0.7	32.872	12.828
0.8	38.355	14.896
0.9	43.984	16.994
1.0	49.739	19.121
1.1	55.619	21.273
1.2	61.632	23.448
1.3	67.796	25.646
1.4	74.132	27.863
1.5	80.667	30.100
1.6	87.428	32.354
1.7	94.446	34.625
1.8	101.750	36.912
1.9	109.374	39.214
2.0	117.353	41.531
2.1	125.720	43.862

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TABLE XV (cont)

FLOW RATE (SCFM)	NET DIFFERENTIAL PRESSURE (PSID) TEST SPECIMEN INLET PRESSURE (PSIA) 412.6[A]	1006.8[B]
2.2	134.514	46.206
2.3	143.773	48.562
2.4	153.536	50.931
2.5	163.847	53.311
2.6	174.749	55.703
2.7	186.290	58.106
2.8	198.518	60.520
2.9	211.487	62.944
3.0	225.251	65.377
3.1	239.871	67.821
3.2	255.407	70.274
3.3	271.926	72.736
3.4	289.501	75.207
3.5	308.205	77.686

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (differential pressure)} = a + b\ (\text{SCFM}) + c\ (\text{SCFM})^2 + d\ (\text{SCFM})^3 + e\ (\text{SCFM})^4$$

A. $$\text{Log (differential pressure)} = 1.696699 + 1.169452\ (\text{SCFM}) + 0.056939\ (\text{SCFM})^2 + 0.210508\ (\text{SCFM})^3 + 1.199725\ (\text{SCFM})^4$$

Sigma = 0.884

B. $$\text{Log (differential pressure)} = 1.281507 + 1.119046\ (\text{SCFM})$$

Sigma: 0.652

*Test specimen subsequently failed during GN_2 impact portion of test

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TABLE XVI

HPOF TEST NO. 6

TEST SPECIMEN S/N 3*

CLEAN CONDITION - PRE GN_2 IMPACT FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE (Kg/hr)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential) — TEST SPECIMEN INLET PRESSURE (Kg/sq cm) 29.008[A]	70.788[B]
0.5	0.861	0.290
1.0	1.628	0.630
1.5	2.512	0.991
2.0	3.510	1.368
2.5	4.622	1.756
3.0	5.845	2.153
3.5	7.178	2.559
4.0	8.622	2.971
4.5	10.176	3.390
5.0	11.839	3.814
5.5	13.612	4.244
6.0	15.495	4.678

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log } (\text{Kg/cm}^2 \text{ differential} = a + b\ (\text{Kg/hr}) + c\ (\text{Kg/hr})^2$$

A. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = 0.211713 + 1.014138\ (\text{Kg/hr}) + 0.312667\ (\text{Kg/hr})^2$

Sigma = 0.363

B. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = -0.200865 + 1.119208\ (\text{Kg/hr})$

Sigma = 0.173

*Test specimen subsequently failed during GN_2 impact portion of test

TABLE XVII
HPOF TEST NO. 6
TEST SPECIMEN S/N 3*

CLEAN CONDITION - PRE GN_2 IMPACT FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE (liters/min)**	NET DIFFERENTIAL PRESSURE (Kg/cm² Differential) TEST SPECIMEN INLET PRESSURE (Kg/cm²) 29.008[A]	70.788[B]
0.1	-------	0.308
0.2	-------	0.608
0.3	-------	0.929
0.4	1.275	1.268
0.5	1.578	1.624
0.6	1.899	1.997
0.7	2.238	2.385
0.8	2.594	2.788
0.9	2.968	3.206
1.0	3.360	3.636
1.1	3.769	4.079
1.2	4.196	4.535
1.3	4.640	5.004
1.4	5.102	5.484
1.5	5.581	-------
1.6	6.077	-------
1.7	6.590	-------
1.8	7.121	-------
1.9	7.669	-------
2.0	8.235	-------

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TABLE XVII (cont.)

FLOW RATE (liters/min)**	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential) — TEST SPECIMEN INLET PRESSURE (Kg/cm^2): 29.008[A]	70.788[B]
2.1	8.817	--------
2.2	9.418	--------
2.3	10.035	--------
2.4	10.670	--------
2.5	11.322	--------
2.6	11.992	--------
2.7	12.679	--------
2.8	13.384	--------
2.9	14.107	--------
3.0	14.847	--------

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log }(Kg/cm^2 \text{ differential}) = a + b\,(\text{liters/min}) + c\,(\text{liters/min})^2$$

A. $\text{Log }(Kg/cm^2 \text{ differential}) = 0.560626 + 1.202002\,(\text{liters/min}) + 0.130507\,(\text{liters/min})^2$

Sigma = 0.152

B. $\text{Log }(Kg/cm^2 \text{ differential}) = 0.526369 + 1.191875\,(\text{liters/min}) + 0.336429\,(\text{liters/min})^2$

Sigma = 0.366

*Test specimen subsequently failed during GN_2 impact portion of test.

**At test specimen inlet pressure.

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TABLE XVIII

HPOF TEST NO. 6

TEST SPECIMEN S/N 3*

CLEAN CONDITION - PRE GN_2 IMPACT FLOW RATE VERSUS DIFFERENTIAL PRESSURE TEST

FLOW RATE (lbs GN_2/hour)	NET DIFFERENTIAL PRESSURE (PSID) TEST SPECIMEN INLET PRESSURE (PSIA)	
	412.6[A]	1006.8[B]
1.0	13.146	3.697
1.5	15.960	5.820
2.0	20.746	8.031
3.0	32.390	12.643
4.0	45.207	17.445
5.0	58.718	22.395
6.0	72.990	27.464
7.0	88.293	32.636
8.0	104.977	37.897
9.0	123.437	43.238
10.0	144.109	48.649
11.0	167.473	54.126
12.0	194.067	59.662
13.0	224.497	65.254
14.0	259.458	70.898
15.0	299.746	76.589

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (differential Pressure)} = a + b\,(\log \text{lbs } GN_2/\text{hr}) + c\,(\log \text{lbs } GN_2/\text{hr})^2 + d\,(\log \text{lbs } GN_2/\text{hr})^3 + e\,(\log \text{lbs } GN_2/\text{hr})^4$$

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TABLE XVIII (cont.)

A. $\text{Log (differential pressure)} = 1.118785 + 0.103832\ (\text{log lbs } GN_2/\text{hr}) + 2.594326\ (\text{log lbs } GN_2/\text{hr})^2 - 2.862557\ (\text{log lbs } GN_2/\text{hr})^3 + 1.204304\ (\text{log lbs } GN_2/\text{hr})^4$

Sigma = 0.883

B. $\text{Log (differential pressure)} = 0.567818 + 1.119259\ (\text{log lbs } GN_2/\text{hr})$

Sigma = 0.650

*Test specimen subsequently failed during GN_2 impact portion of test.

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White Sands Test Facility to cover the failure of the HPOF S/N 3.

The contaminant tolerance test #11 was performed using HPOF S/N 020 for the test series. Five additions of synthetic contaminants were used for a total accumulated weight of 38.9 mg. Preliminary review of the test data indicated an increase of less than 5 psid in net ΔP over a flow range of 1 to 13 lbs. per hour of GN_2.

After the addition of a total of 100.2 milligrams of synthetic contaminant, the differential pressure across the test specimen increased by 28 psid at a flow rate of 6 lbs. per hour of GN_2 with an inlet pressure of 415 psia. The inlet pressure was increased to 1000 psia while maintaining the same flow rate (6#/hr). The differential pressure across the test specimen reduced to 7 psid.

Two of the final configuration (TIG welded sleeve) specimens (S/N's 023 and 024) were subjected to DCT Test No. 5, "Clean Condition-Flow Rate versus Differential Pressure" tests to determine the pressure drop characteristics of the new configuration. The tests indicated that the net differential pressure of the new configuration was approximately 36 psid higher than the old configuration while flowing 6 lbs/hr with an inlet pressure of 415 psia.

Speciem S/N 024 was subjected to a shortened Design Certification Test (DCT)*6 "Clean Condition-Impact/Flow Rate versus Differential Pressure" test series. After completing 80 high pressure (10,000 psia normal) impact

cycles, the post impact flow rate versus differential pressure portion of DCT #6 was performed. The differential pressure had decreased approximately 50% from values observed during pre-impact flow tests.

Specimen S/N 021 was subjected to Design Certification (DCT) #6 "Clean Condition - Impact/Flow Rate versus Differential Pressure" test. The pre-impact flow differential pressure was 106 psid at a flow rate of 6 lbs/hr with an inlet pressure of 415 psia. The specimen was subjected to one hundred 10,000 psid GN_2 impact cycles. A post impact test clean flow differential pressure test series was conducted. The net differential pressure of this unit was 46 psid at a flow rate of 6 lbs GN_2/hour with an inlet pressure of 415 psia test specimen inlet pressure. This is approximately 50% less differential pressure than that observed prior to clean impact flow of specimen S/N 021 at the same flow condition.

Specimen S/N's 022, 023 and 025 were subjected to Design Certification Test (DCT) #5, "Clean Condition - Flow Rate versus Differential Pressure" tests in the forward flow direction (S/N side facing upstream). Review of the data indicated that the three units exhibited similar pressure drop characteristics at specimen inlet pressures of 415, 700 and 1000 psia.

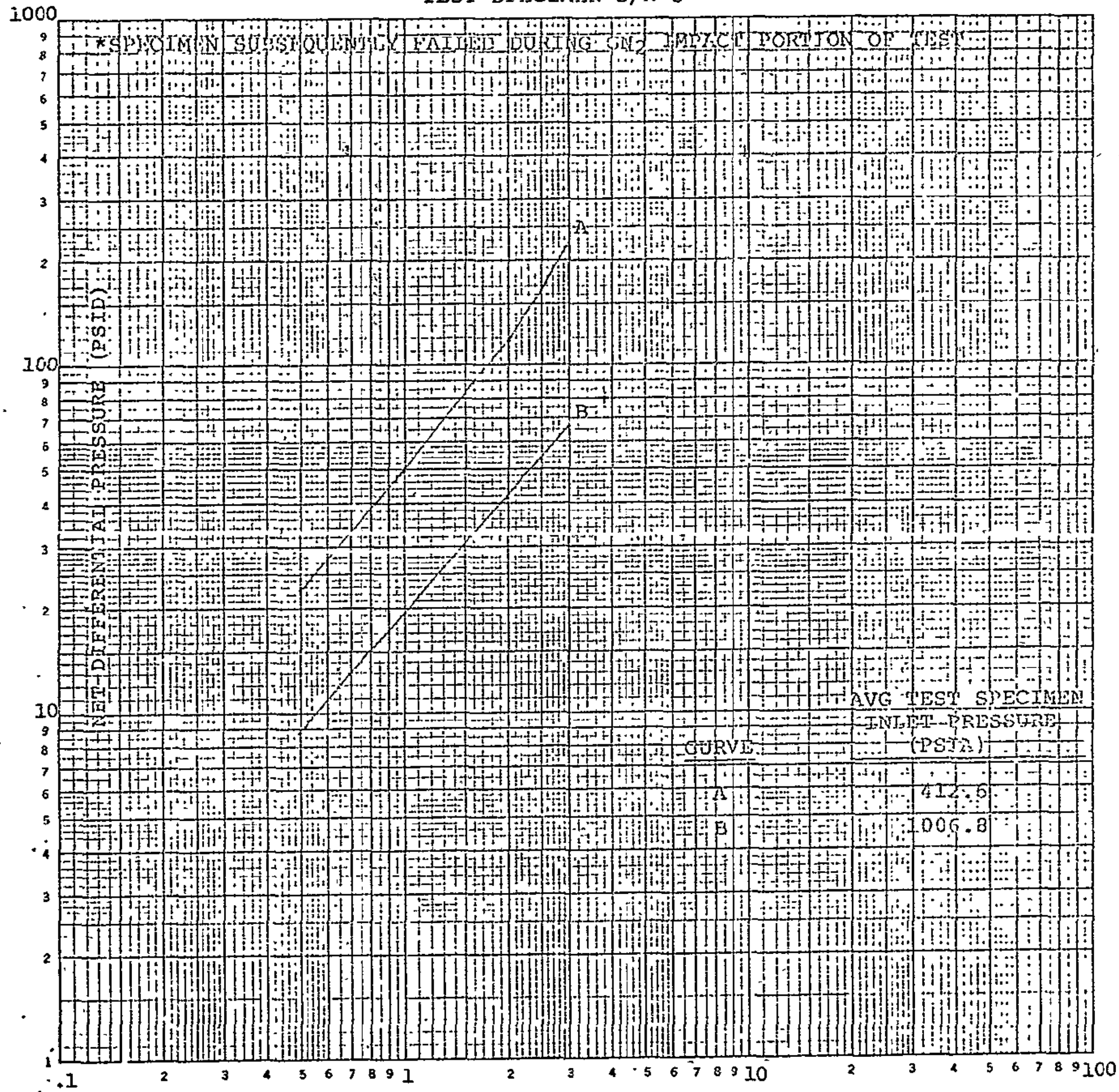
Specimen S/N's 023 and 025 were subjected to "Clean Condition-Flow Rate versus Differential Pressure" tests in the reverse flow direction (S/N side facing downstream). The specimen inlet pressures were 415 and 1000 psia GN_2. Preli-

FIGURE 22

HPOF PROGRAM TEST NO. 6

CLEAN CONDITION - PRE GN_2 IMPACT FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 3*



FLOW RATE (SCFM)

FIGURE 23

HPOF PROGRAM TEST NO. 6

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CLEAN CONDITION - PRE GN_2 IMPACT FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 3*

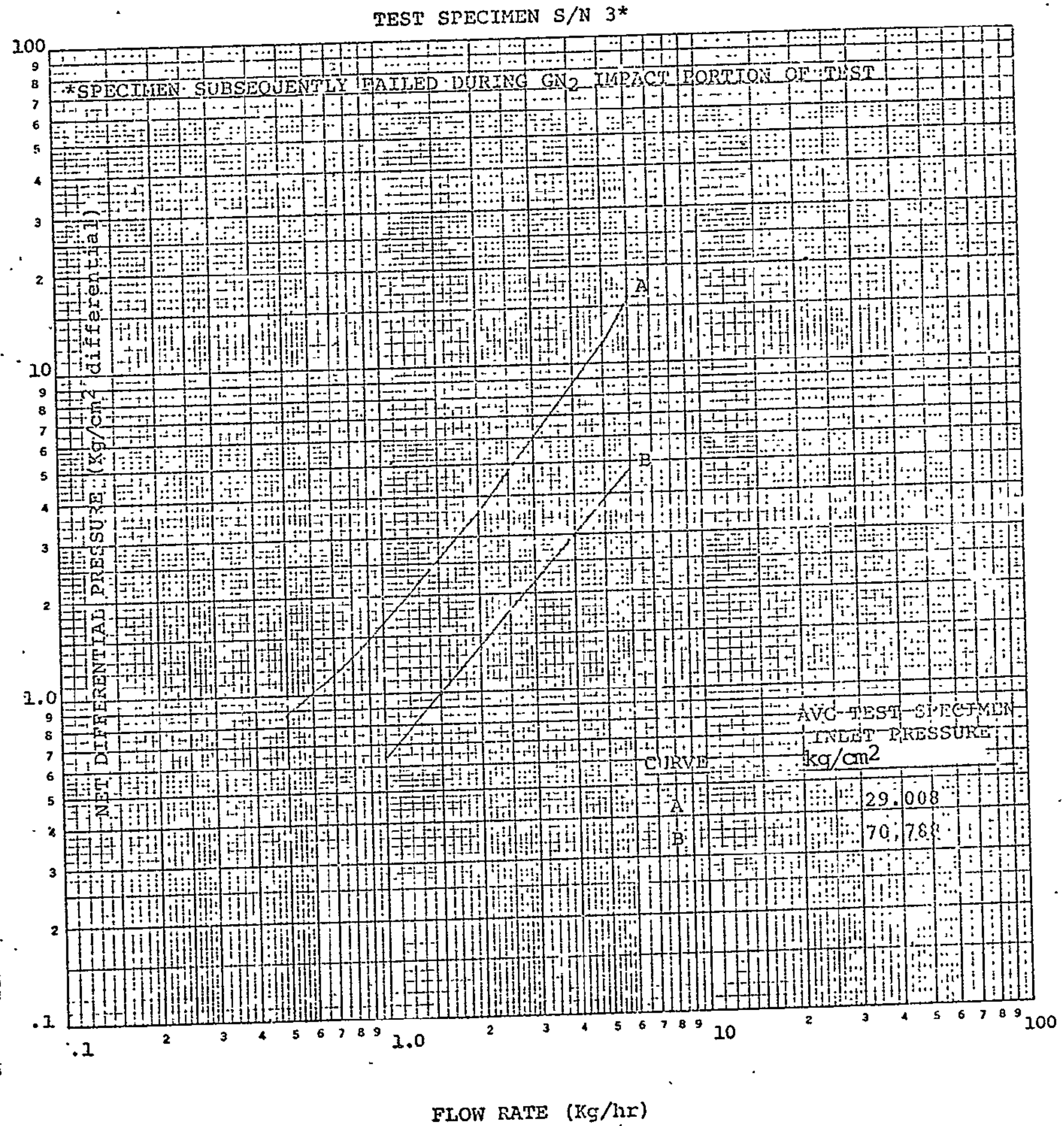

FIGURE 24

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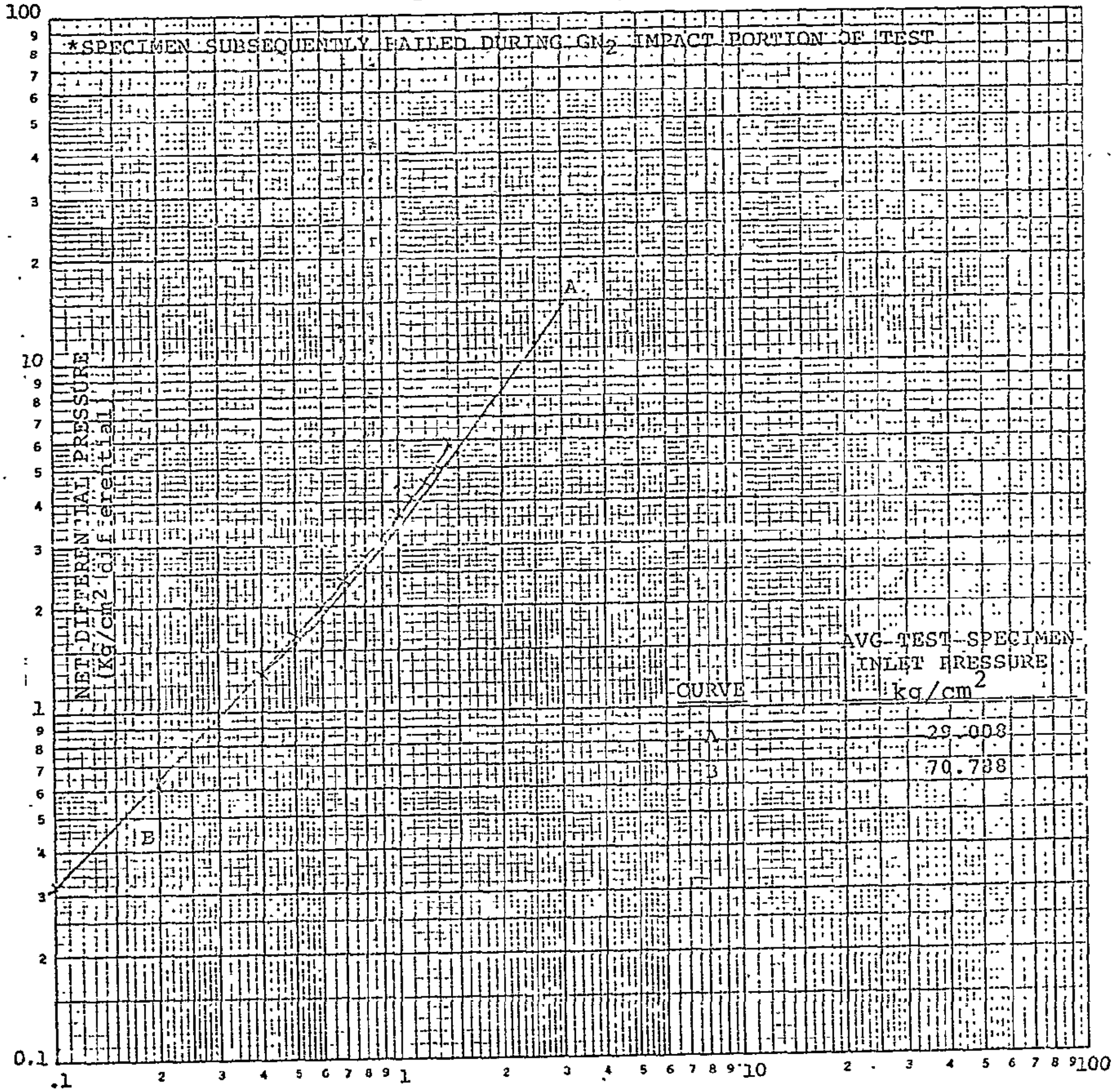
HPOF PROGRAM TEST NO. 6

CLEAN CONDITION - PRE GN_2 IMPACT FLOW RATE
VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 3*



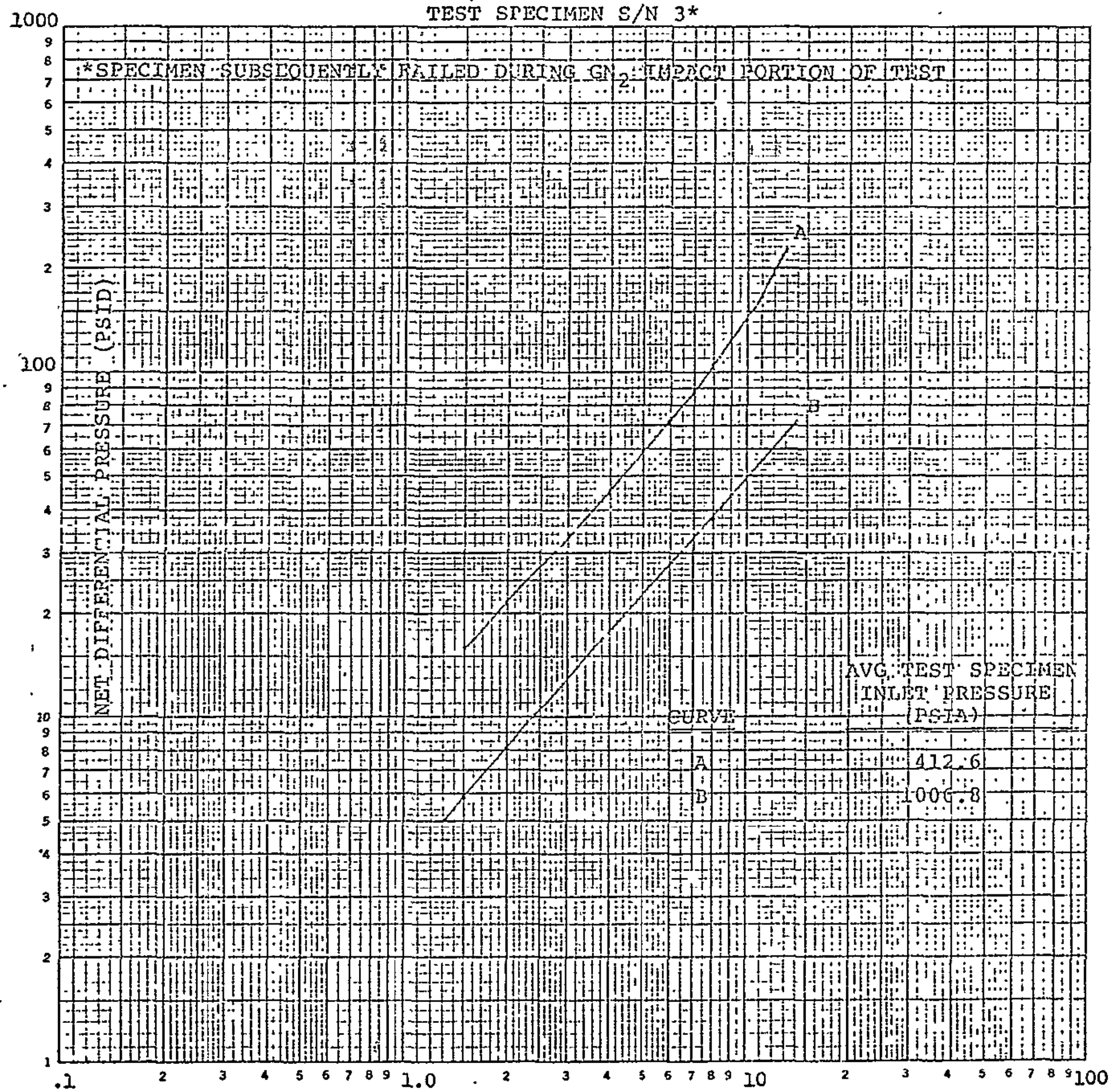
FLOW RATE (LITERS/MIN AT TEST SPECIMEN INLET PRESSURE)

FIGURE 25

HPOF PROGRAM TEST NO. 6

CLEAN CONDITION - PRE GN_2 IMPACT FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 3*



FLOW RATE (lbs GN_2/hour)

minary review of the data indicated the differential pressure was 100% higher than the differential pressure with the flow in the forward direction with the same parametric values.

Design Certification Test (DCT) #4 "Vibration Test" was performed using specimen S/N 025. This test was conducted to evaluate the media migration characteristics of the HPOF. Examination of data[5] indicated satisfactory performance of the HPOF under vibratory conditions.

Specimen S/N 023 was subjected to a DCT #7, "Contaminant Transmission Test" series. Tests were conducted to obtain flow pressure drop data before and after 10 high pressure (10,000 psia nominal) GN_2 impact cycles. Data evaluation indicated that the 10 high pressure GN_2 impact cycles results in a 50% reduction in differential pressure in the forward flow direction at a given flow condition. The differential pressure in the reverse flow direction was significantly higher after th 10 high pressure GN_2 impact cycles. Results of the contaminant transmission test using Fe_2O_3 showed that the largest particle transmitted was 10 x 10 microns in size. Numerous particles less than three (3) microns in size were initially transmitted through the specimen. However, the quantity of particles transmitted were reduced with subsequent additions of the Fe_2O_3 contaminant.

Specimen S/N 022 was subjected to Design Certification Test (DCT) #11, "Contaminated Condition - Flow Rate versus Differential Pressure" tests to evaluate the contaminant capacity of the HPOF under simple gas flow conditions.

Approximately 100 milligrams of synthetic contaminant was added to the flow system on the upstream side of the test specimen. Examination of the data indicates the differential pressure at a given amount of contaminant addition is higher with the new configuration S/N 022 than that experienced with the prior configuration S/N 020.

Analysis of the contaminant transmission data obtained during the DCT #8, "Contaminant Transmission Test", with specimen S/N 025 indicated the maximum size particle of Fe_2O_3 contaminant was 10 x 10 microns.

DCT #10 Contaminated Condition - Impact/Flow Rate versus Differential Pressure" Test using the pre-mixed synthetic contaminant was conducted with specimen S/N 027. The test was conducted to evaluate the contaminant capacity of the HPOF under a combination of high pressure (10,000 psia nominal) GN_2 impact cycles and simple flow conditions. After the addition of 15.8 mg of synthetic contaminants to the upstream side of the specimen and the application of 20 high pressure GN_2 impact cycles, normal flow rates could not be maintained with inlet pressures of 415 and 1000 psia. The results of this test indicated that the application of high pressure GN_2 impact cycles had a detrimental effect upon a HPOF contaminated with synthetic contaminants, probably due to the teflon content of the contaminant.

Test Specimen S/N 023 was subjected to a series of Clean Condition - Flow Rate versus Differential Pressure and Contaminated Condition -Impact/Flow Rate versus Differential Pressure tests in accordance with DCT #12. The tests were

conducted to determine the effects of high pressure impact GN_2 cycles upon a HPOF contaminated with synthetic contaminants. The tests were conducted in both flow directions. The amount of contaminants and the number of impact cycles were reduced for this series.

Specimen S/N 029 successfully completed the required proof and burst tests.

8-5 DATA

Data from clean flow rate versus differential pressure tests on HPOF specimens S/N 006 and 003 have been presented and discussed in Section 8-4 and will not be duplicated here. Data from the balance of the test series is reviewed in the following paragraphs.

Figures 26 through 29 graphically show the Clean Condition -Flow Rate versus Differential Pressure data for test specimen S/N 020. Tables XIX through XXII show the data in tabular form.

Figures 30 through 37 graphically show the Contaminated Condition - Flow Rate versus Differential Pressure data for test specimen S/N 020. Tables XXIII through XXX show the data in tabular form.

Figures 38 through 41 graphically show the Clean Condition -Flow Rate versus Differential Pressure data for test specimen S/N 023. Tables XXXI through XXXIV show the data in tabular form.

Figures 42 through 61 graphically show the Clean Condition - Flow Rate versus Differential Pressure data (42-45)

prior to impact test; Clean Condition - Impact/Flow Rate versus Differential Pressure data (46-49) after 80 high pressure impact cycles; and Clean Condition - Impact/Flow Rate versus Differential Pressure comparison data (50-61) for test specimen S/N 024. Tables XXXV through XLIII show the data in tabular form.

The data mentioned in the foregoing paragraph are from tests conducted at JSC-WSTF.

Table XLIV outlines the sequence of tests conducted at Wintec in an effort to determine the effects of proof loading upon the flow and bubble point characteristics of the HPOF. Table XLV is the data that was obtained from the test sequence noted in Table XLIV.

Figures 62 through 73 graphically show the flow rate versus differential pressure data obtained prior to and after 100 high pressure GN_2 impact cycles for specimen S/N 021. Tables XLVI through XLIX show the data in tabular form. Table L is a summary of impact pressures.

Figures 94 thru 101 graphically show the Clean Condition - Flow Rate versus Differential Pressure data for specimen S/N 023. The tests were conducted in the forward and reverse flow directions. Tables LXVII through LXXIV show the data in tabular form.

Figures 102 through 109 show the Contaminated Condition - Flow Rate versus Differential Pressure Data for test specimen S/N 022. Tables LXXV through LXXXII show the data in tabulated form.

Figures 110 thru 117 show the Contaminated Condition - Impact Flow Rate versus Differential Pressure data for test specimen S/N 028. Tables LXXXIII through XC show the data in tabular form.

SECTION 9

CONCLUSIONS

The following conclusions and recommendations are presented as a result of the effort performed under this program.

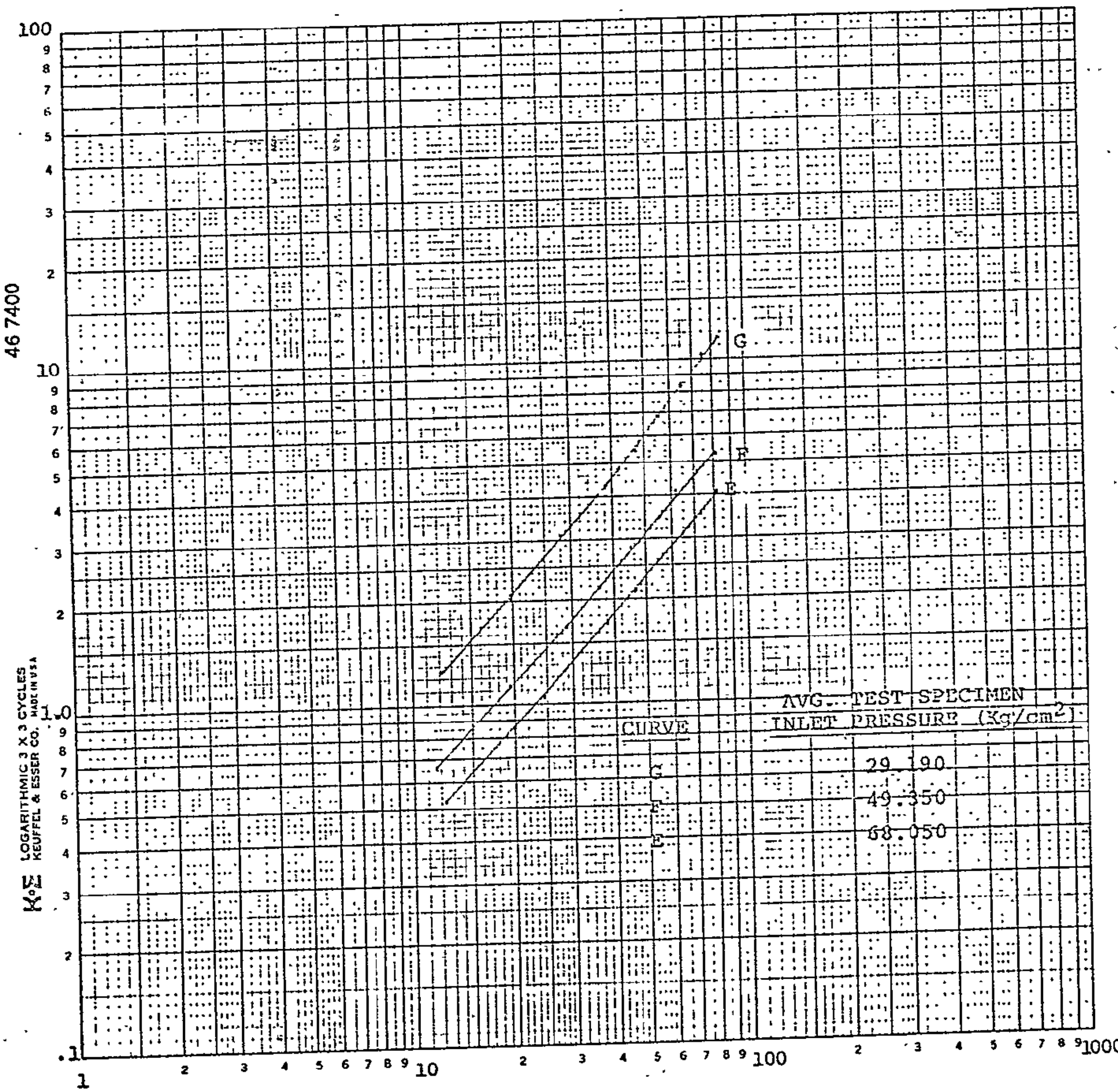
1. Wintec P/N 9-812 High Pressure Oxygen Filter (HPOF) represents the ultimate in state-of-the-art high pressure gas filters of low micron rating combined with structural capacity for 10,000 psi shock conditions.
2. Wintec P/N 9-812 has been thoroughly and effectively qualified for use in these systems.
3. Storage vessels in gas systems should be cleaned to much higher levels of cleanliness than levels presently specified.
4. Storage vessel design should be optimized to give suitable size exit and entry ports for cleaning to be readily accomplished.
5. HPOF type filters should be installed in outlet of the valve rather than the inlet of the regulator in systems which have tubing connections between the two components.
6. Optimize fitting and cavity design related to the use and installation of teflon "O" rings and Delta seals to minimize the gouging and cutting of these seals by sharp metallic edges.

Figure 26

HPOF PROGRAM TEST NO. 5

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 020



FLOW RATE (liters*/min)

*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

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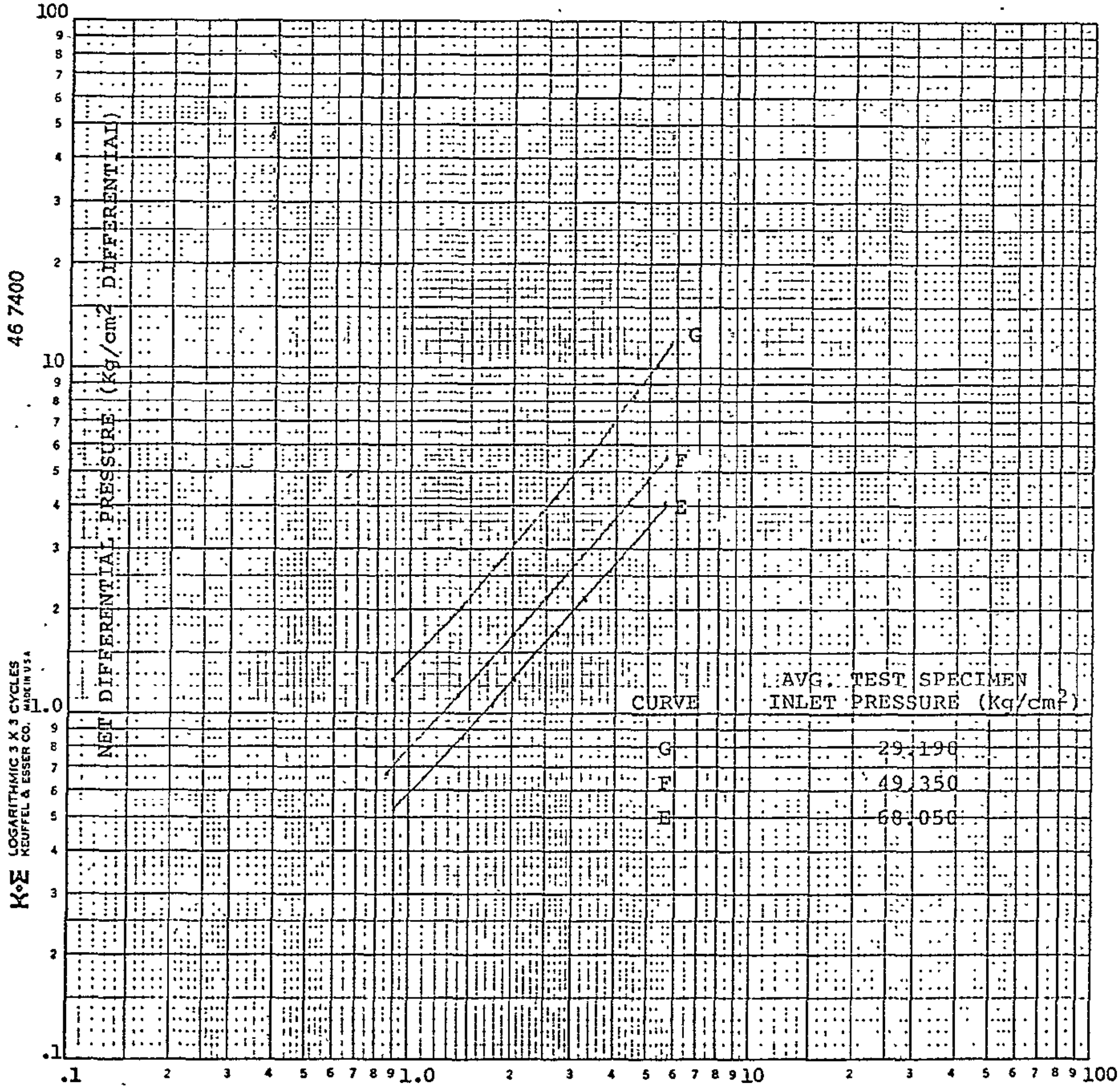
Figure 27

HPOF PROGRAM TEST NO. 5

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 020



FLOW RATE (Kg/hour)

Figure 28

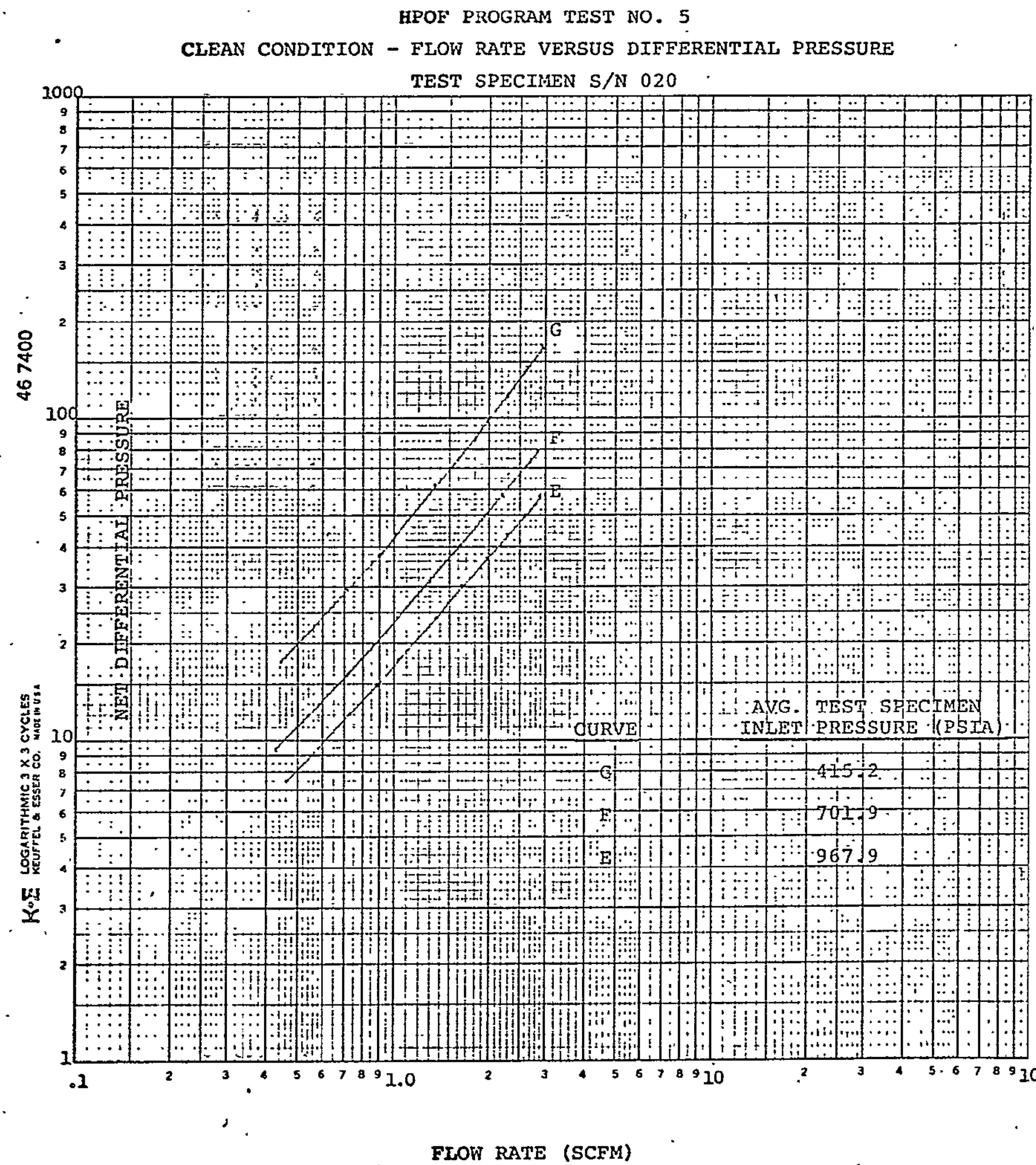
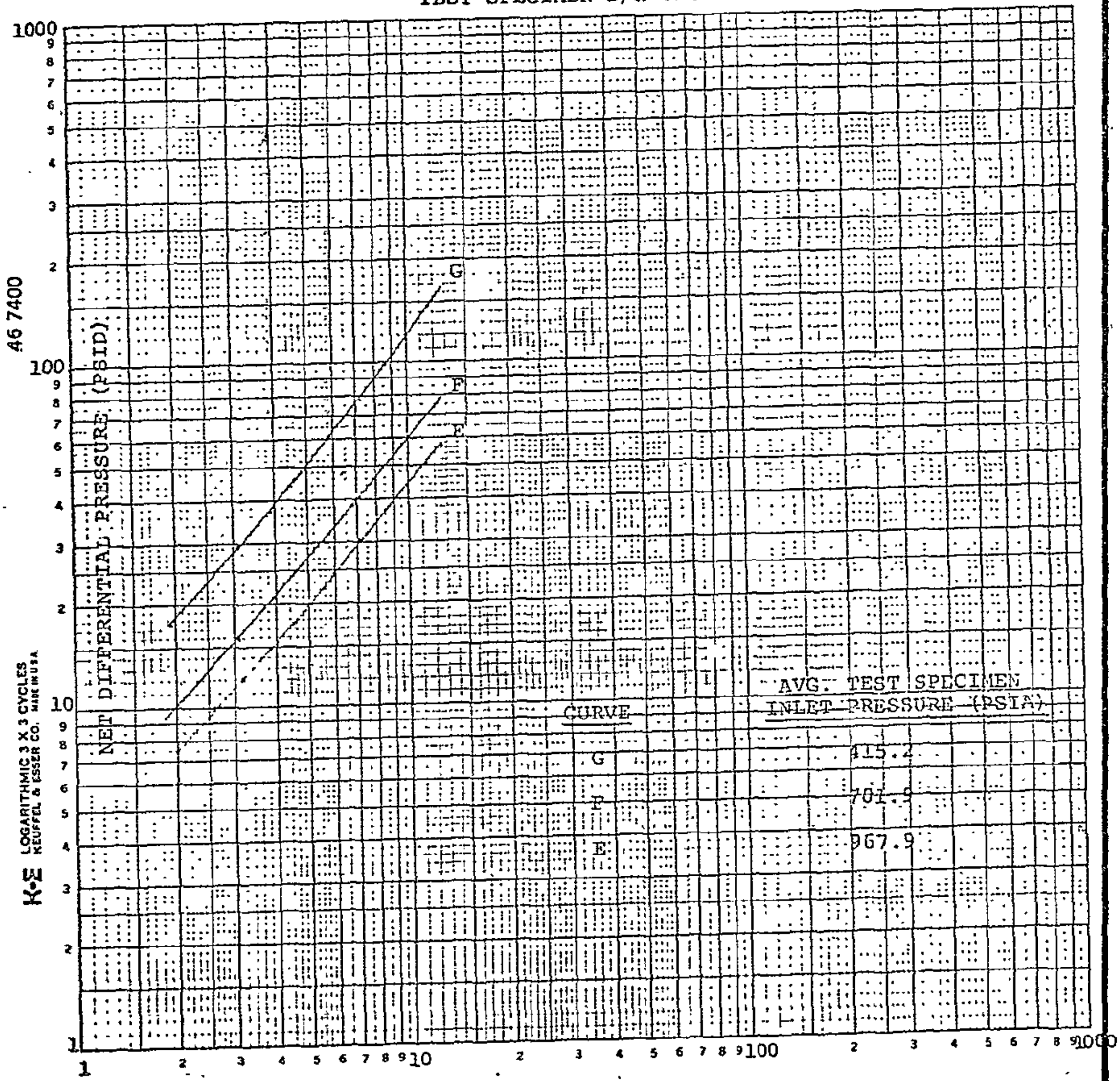

HPOF PROGRAM TEST NO. 5
CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
TEST SPECIMEN S/N 020
NET DIFFERENTIAL PRESSURE
FLOW RATE (SCFM)
G
F
E
CURVE
AVG. TEST SPECIMEN INLET PRESSURE (PSIA)
G 415.2
F 701.9
E 967.9
46 7400
K&E LOGARITHMIC 3 X 3 CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.

Figure 29

HPOF PROGRAM TEST NO. 5

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 020



FLOW RATE (lbs GN_2/Hour)

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Table XIX

TEST NO. 5

HPOF TEST SPECIMEN S/N 020

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE (liters GN_2/min)*	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential)		
	TEST SPECIMEN INLET PRESSURE (Kg/cm^2)		
	29.190^A	49.350^B	68.050^C
10	0.995	0.568	0.421
15	1.525	0.857	0.634
20	2.065	1.157	0.854
25	2.626	1.466	1.081
30	3.212	1.785	1.315
35	3.829	2.112	1.556
40	4.478	2.448	1.803
45	5.163	2.792	2.056
50	5.884	3.142	2.314
55	6.645	3.500	2.578
60	7.446	3.865	2.847
65	8.289	4.236	3.120
70	9.176	4.614	3.399
75	10.108	4.998	3.682
80	11.086	5.388	3.970
85	12.113	5.783	4.262
90	13.188	6.184	4.558
95	14.314	6.591	4.859
100	15.493	7.003	5.163

*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log } (\text{Kg/cm}^2 \text{ differential}) = a + b\,(\text{log liters } GN_2/\text{min}) + c\,(\text{log liters } GN_2/\text{min}) + d\,(\text{log liters } GN_2/\text{min})^3$$

A. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = -1.412082 + 1.990013\,(\text{log liters } GN_2/\text{min}) - 0.816113\,(\text{log liters } GN_2/\text{min})^2 + 0.235829\,(\text{log liters } GN_2/\text{min})^3$

Sigma = 0.059

B. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = -1.148831 + 0.809823\,(\text{log liters } GN_2/\text{min}) + 0.093616\,(\text{log liters } GN_2/\text{min})^2$

Sigma = 0.019

C. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = -1.264332 + 0.789478\,(\text{log liters } GN_2/\text{min}) + 0.099574\,(\text{log liters } GN_2/\text{min})^2$

Sigma = 0.006

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Table XIX

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Table XX

TEST NO. 5

HPOF TEST SPECIMEN S/N 020

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE ($Kg\ GN_2/hr$)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential) TEST SPECIMEN INLET PRESSURE (Kb/sq cm) 29.190[A]	49.350[B]	68.050[C]
0.5	0.627	0.386	0.286
1.0	1.399	0.788	0.582
1.5	2.178	1.216	0.898
2.0	2.996	1.668	1.230
2.5	3.873	2.140	1.578
3.0	4.819	2.630	1.939
3.5	5.845	3.138	2.313
4.0	6.958	3.662	2.698
4.5	8.164	4.201	3.095
5.0	9.471	4.754	3.503
5.5	10.884	5.321	3.920
6.0	12.410	5.900	4.348

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log }(\text{Kg/cm}^2\text{ differential}) = a + b\,(\log \text{Kg } GN_2/\text{hr}) + c\,(\log \text{Kg } GN_2/\text{hr})^2 + d\,(\log \text{Kg } GN_2/\text{hr})^3$$

A. $\text{Log }(\text{Kg/cm}^2\text{ differential}) = 0.145693 + 1.099554\,(\log \text{Kg } GN_2/\text{hr}) - 0.098008\,(\log \text{Kg } GN_2/\text{hr})^2 + 0.322142\,(\log \text{Kg } GN_2/\text{hr})^3$

Sigma = 0.065

B. $\text{Log }(\text{Kg/cm}^2\text{ differential}) = -0.103538 + 1.05526\,(\log \text{Kg } GN_2/\text{hr}) + 0.087629\,(\log \text{Kg } GN_2/\text{hr})^2$

Sigma = 0.016

C. $\text{Log }(\text{Kg/cm}^2\text{ differential}) + -0.234785 + 1.051610\,(\log \text{Kg } GN_2/\text{hr}) + 0.090361\,(\log \text{Kg } GN_2/\text{hr})^2$

Sigma = 0.006

Table XX

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Table XXI

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TEST NO. 5

HPOE TEST SPECIMEN S/N 020

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE (SCFM)	NET DIFFERENTIAL PRESSURE (PSID) TEST SPECIMEN INLET PRESSURE (PSIA) 415.2[A]	701.9[B]	967.9[C]
0.4	15.265	8.742	6.451
0.5	19.563	11.035	8.142
0.6	23.878	13.387	9.877
0.7	28.242	15.794	11.652
0.8	32.682	18.253	13.465
0.9	37.219	20.763	15.315
1.0	41.870	23.319	17.200
1.1	46.648	25.922	19.117
1.2	51.565	28.568	21.067
1.3	56.631	31.256	23.048
1.4	61.854	33.985	25.059
1.5	67.244	36.753	27.098
1.6	72.807	39.560	29.165
1.7	78.551	42.404	31.260
1.8	84.481	45.284	33.381
1.9	90.604	48.200	35.527
2.0	96.926	51.149	37.699
2.1	103.453	54.133	39.896
2.2	110.190	57.150	42.116
2.3	117.144	60.198	44.361
2.4	124.319	63.279	46.628
2.5	131.721	66.390	48.918
2.6	139.356	69.532	51.230
2.7	147.228	72.704	53.564
2.8	155.345	75.905	55.919
2.9	163.709	79.135	58.295
3.0	172.329	82.393	60.693
3.1	181.208	85.679	63.110
3.2	190.352	88.993	65.548
3.3	199.767	92.334	68.005
3.4	209.459	95.702	70.483
3.5	219.432	99.097	72.979

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\ (\log \text{SCFM}) + c\ (\log \text{SCFM})^2 + d\ (\log \text{SCFM})^3 + e\ (\log \text{SCFM})^4$$

A. $\text{Log (PSID)} = 1.621903 + 1.125428\ (\log \text{SCFM}) + 0.188038\ (\log \text{SCFM})^2 + 0.319323\ (\log \text{SCFM})^3$
Sigma = 0.932

B. $\text{Log (PSID)} = 1.367716 + 1.106307\ (\log \text{SCFM}) + 0.089312\ (\log \text{SCFM})^2$
Sigma = 0.232

C. $\text{Log (PSID)} = 1.235518 + 1.105521\ (\log \text{SCFM}) + 0.088513\ (\log \text{SCFM})^2$
Sigma = 0.088

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Table XXI

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Table XXII

TEST NO. 5

HPOF TEST SPECIMEN S/N 020

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE ($lbs\ GN_2/hr$)	NET DIFFERENTIAL PRESSURE (PSID)		
	TEST SPECIMEN INLET PRESSURE (PSIA)		
	415.2[A]	701.9[B]	967.9[C]
1.0	7.897	4.989	3.694
1.5	12.910	7.512	5.555
2.0	17.870	10.120	7.478
2.5	22.832	12.809	9.459
3.0	27.850	15.571	11.494
3.5	32.964	18.404	13.580
4.0	38.209	21.303	15.715
4.5	43.607	24.264	17.896
5.0	49.181	27.284	20.120
5.5	54.945	30.362	22.386
6.0	60.915	33.494	24.693
6.5	67.103	36.678	27.038
7.0	73.521	39.914	29.420
7.5	80.179	43.198	31.838
8.0	87.087	46.530	34.292
8.5	94.254	49.909	36.780
9.0	101.690	53.332	39.301
9.5	109.403	56.799	41.854
10.0	117.402	60.309	44.438
10.5	125.695	63.861	47.054
11.0	134.291	67.454	49.700
11.5	143.197	71.087	52.375
12.0	152.424	74.759	55.079
12.5	161.977	78.469	57.812
13.0	171.867	82.217	60.572
13.5	182.102	86.002	63.360
14.0	192.689	89.824	66.175
14.5	203.638	93.681	69.016
15.0	214.956	97.574	71.883

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\ (\log \text{ lbs } GN_2/\text{hr}) + c\ (\log \text{ lbs } GN_2/\text{hr})^2 + d\ (\log \text{ lbs } GN_2/\text{hr})^3$$

A. $\text{Log (PSID)} = 0.897436 + 1.277286\ (\log \text{ lbs } GN_2/\text{hr}) - 0.425329\ (\log \text{ lbs } GN_2/\text{hr})^2 + 0.320281\ (\log \text{ lbs } GN_2/\text{hr})^3$

Sigma = 0.929

B. $\text{Log (PSID)} = 0.698017 + 0.993749\ (\log \text{ lbs } GN_2/\text{hr}) + 0.088619\ (\log \text{ lbs } GN_2/\text{hr})^2$

Sigma = 0.230

C. $\text{Log (PSID)} = 0.567535 + 0.990176\ (\log \text{ lbs } GN_2/\text{hr}) + 0.090048\ (\log \text{ lbs } GN_2/\text{hr})^2$

Sigma = 0.089

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TEST NO. 11
CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
TEST SPECIMEN S/N 020

Figure 30

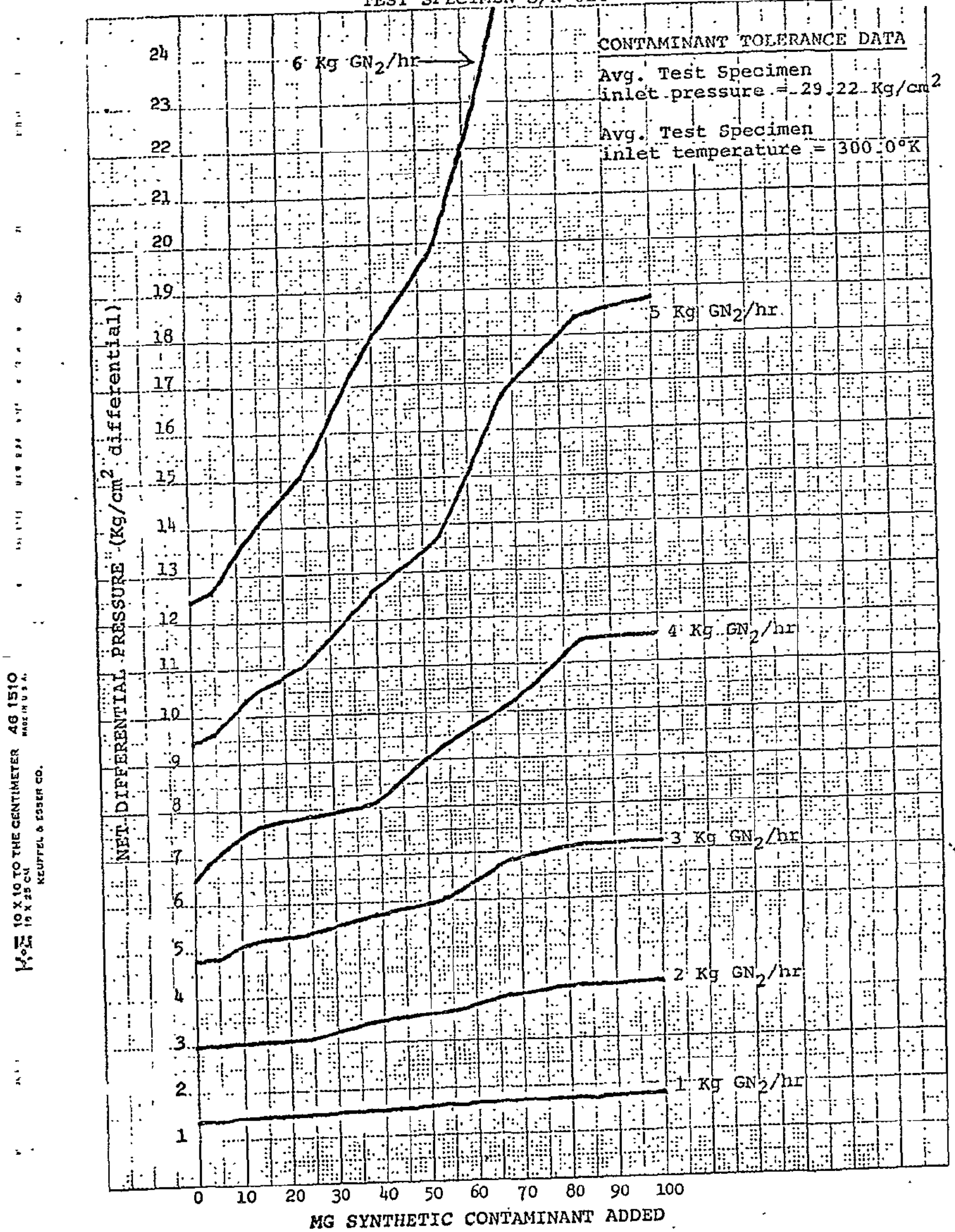

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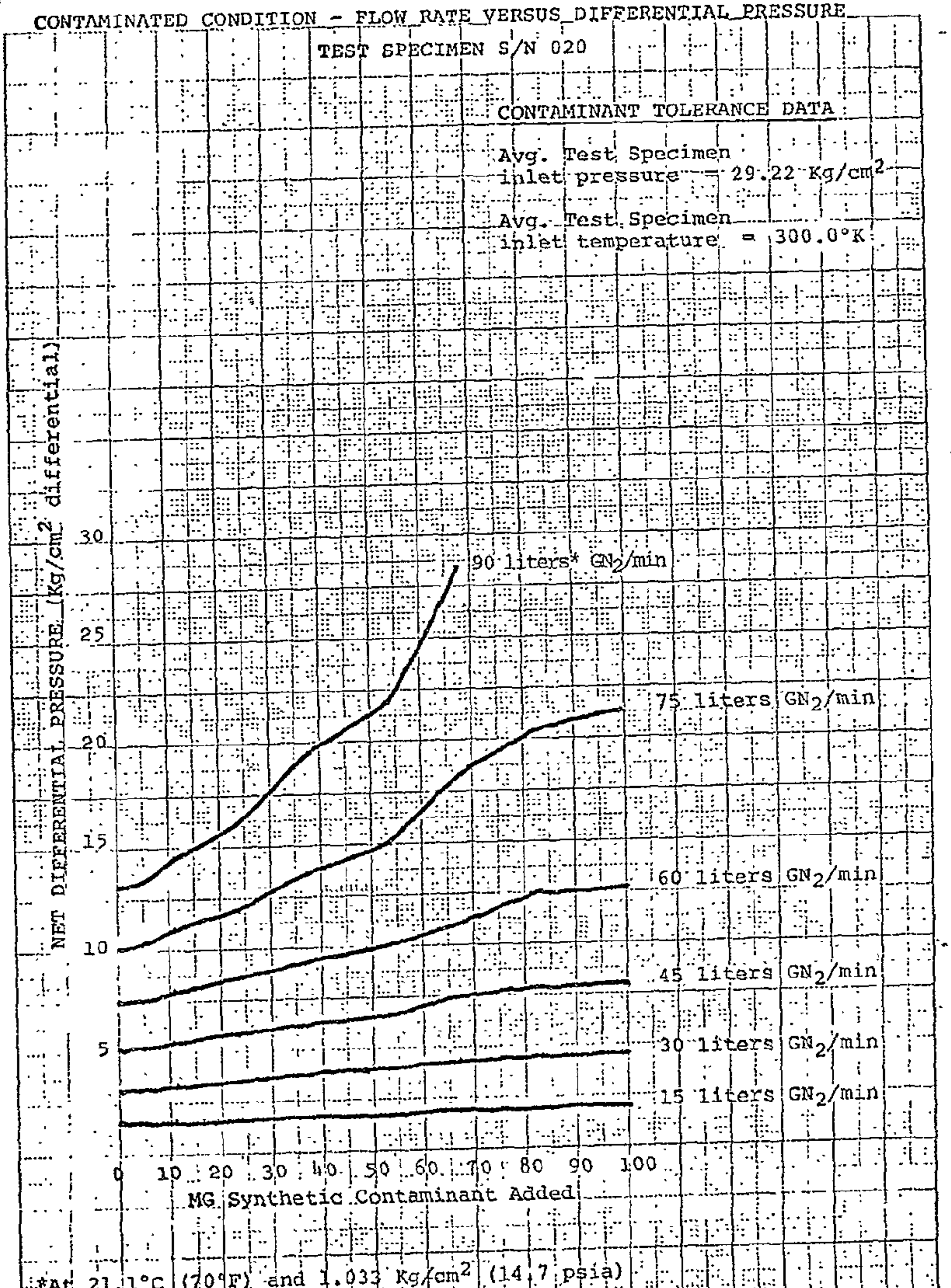
Figure 31

TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 020



*At 21.1°C (70°F) and 1.033 Kg/cm2 (14.7 psia)

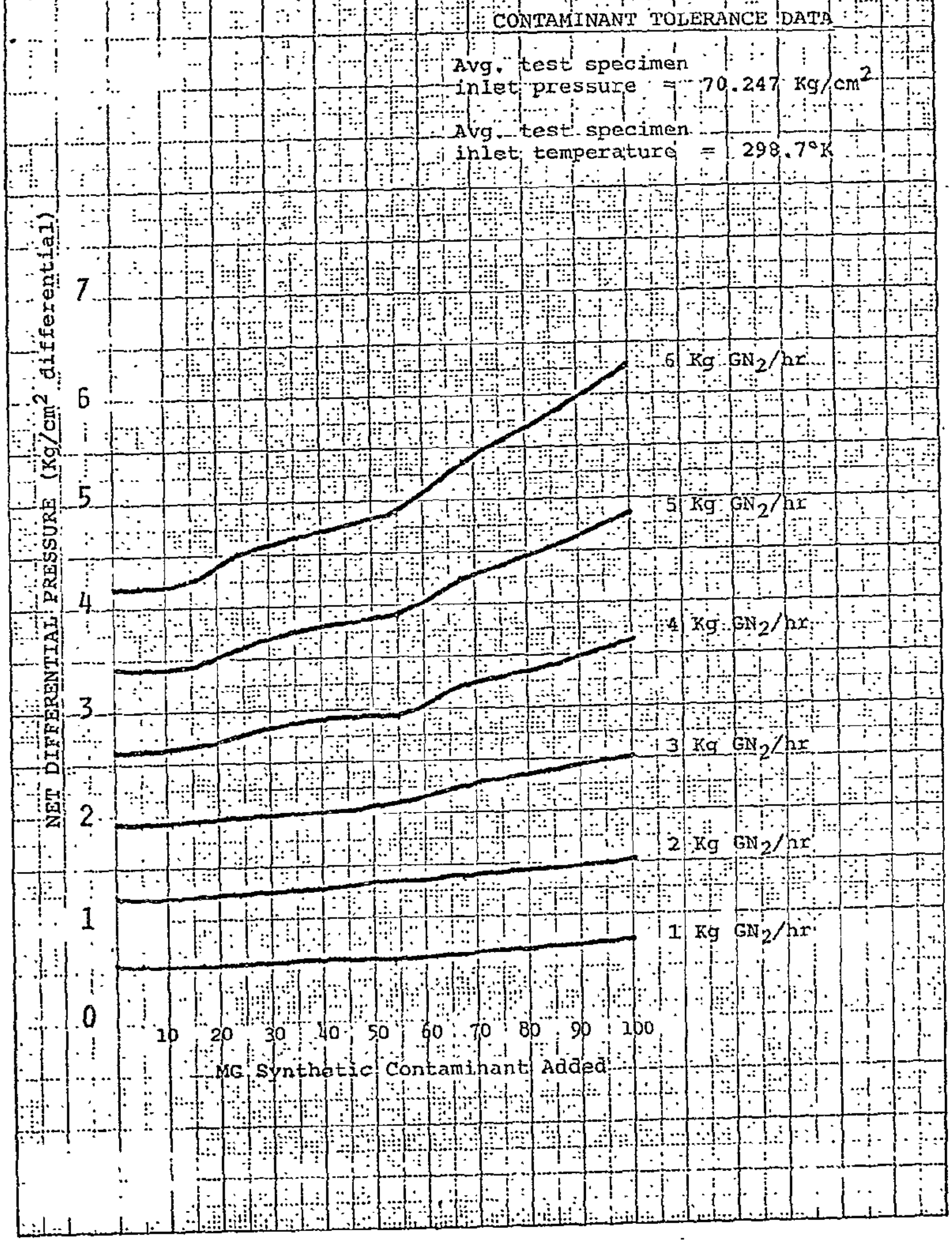
K&E 10 X 10 TO THE CENTIMETER 18 X 25 CM. 46 1510 KEUFFEL & ESSER CO. MADE IN U.S.A.

Figure 32

TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 020



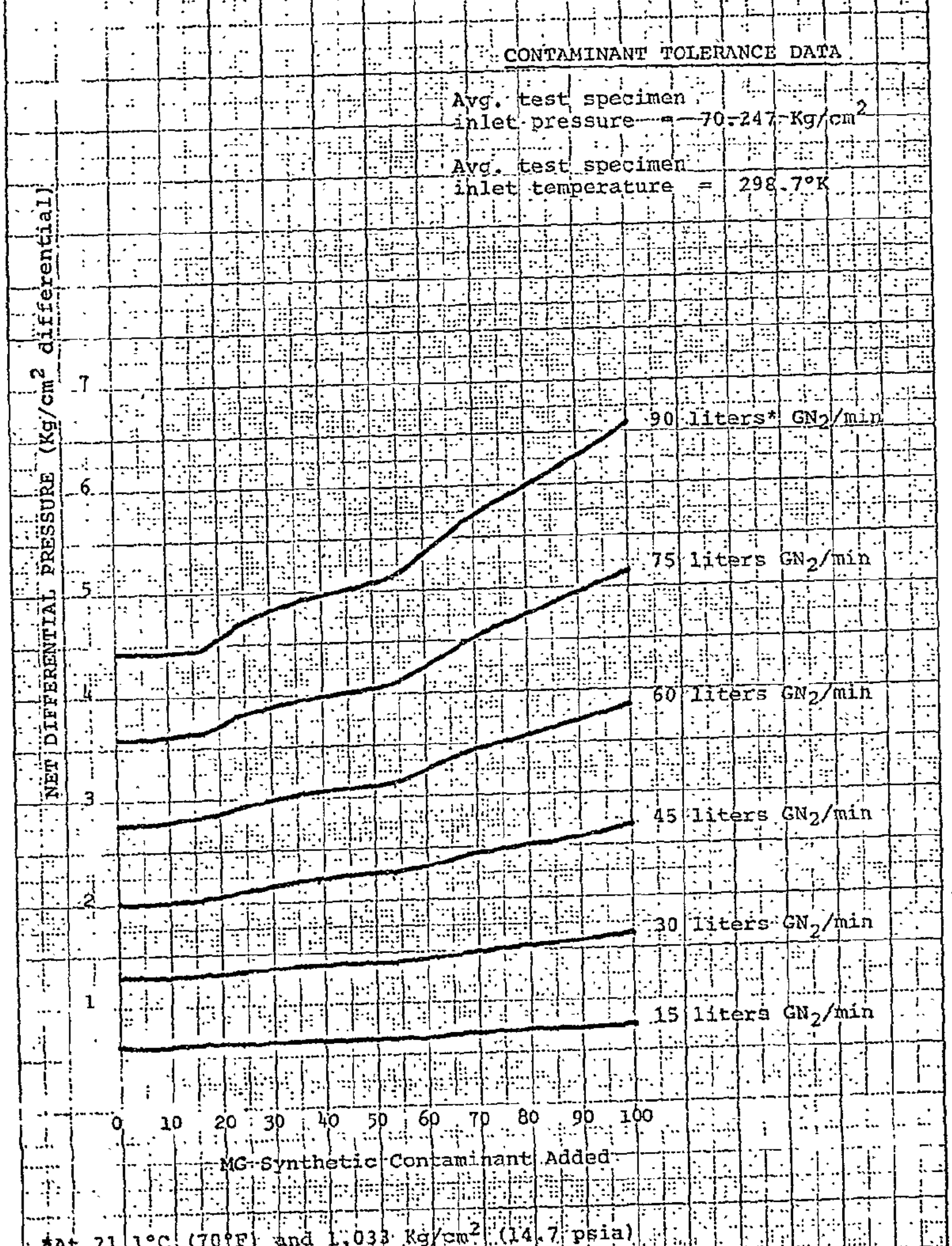
10 X 10 TO THE CENTIMETER 46 1510
18 X 25 CM. KEUFFEL & ESSER CO. MADE IN U.S.A.

Figure 33

TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 020



*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

K&E 10 X 10 TO THE CENTIMETER 46 1510
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

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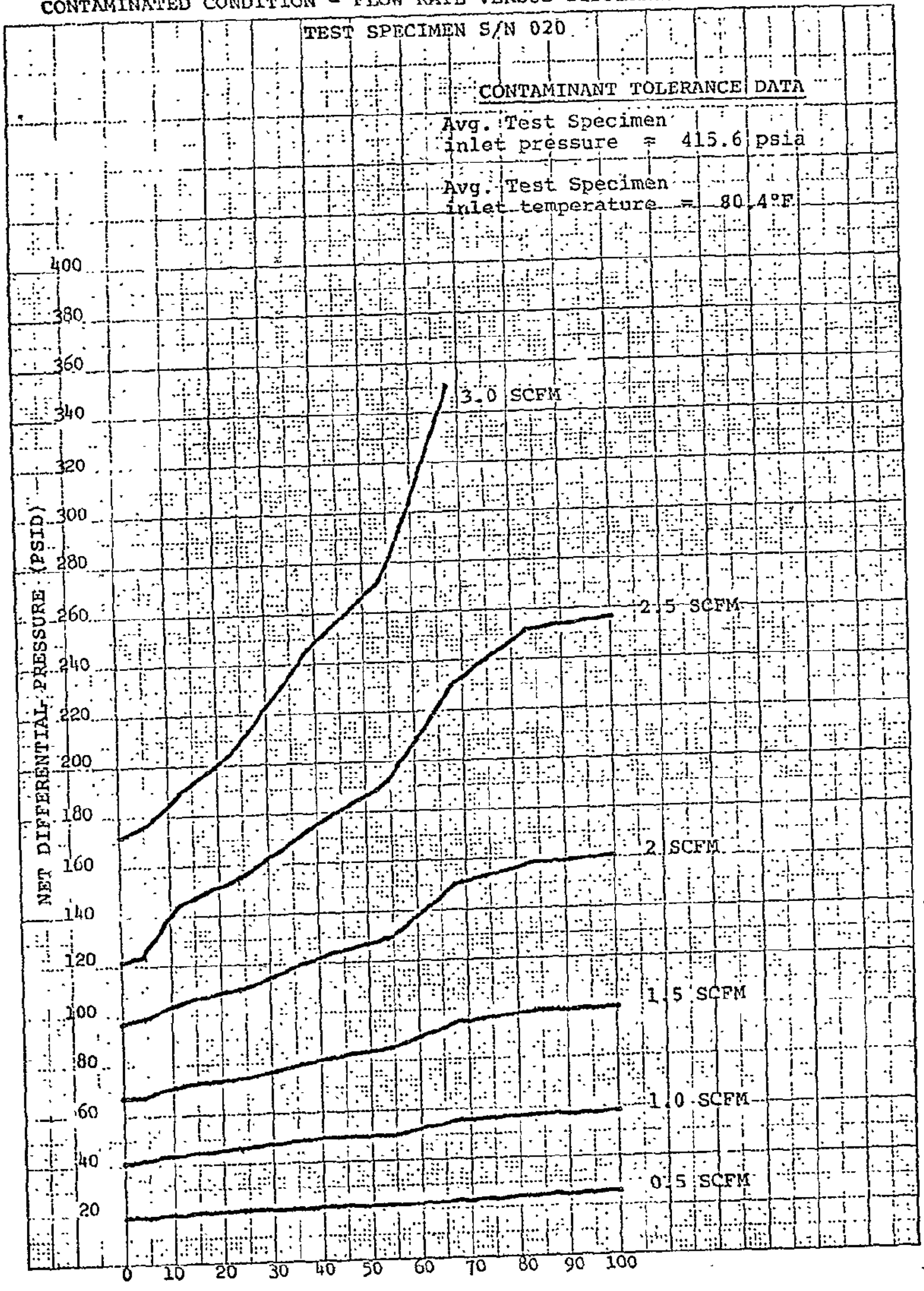
Figure 34

TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE



MG Synthetic Contaminant Added

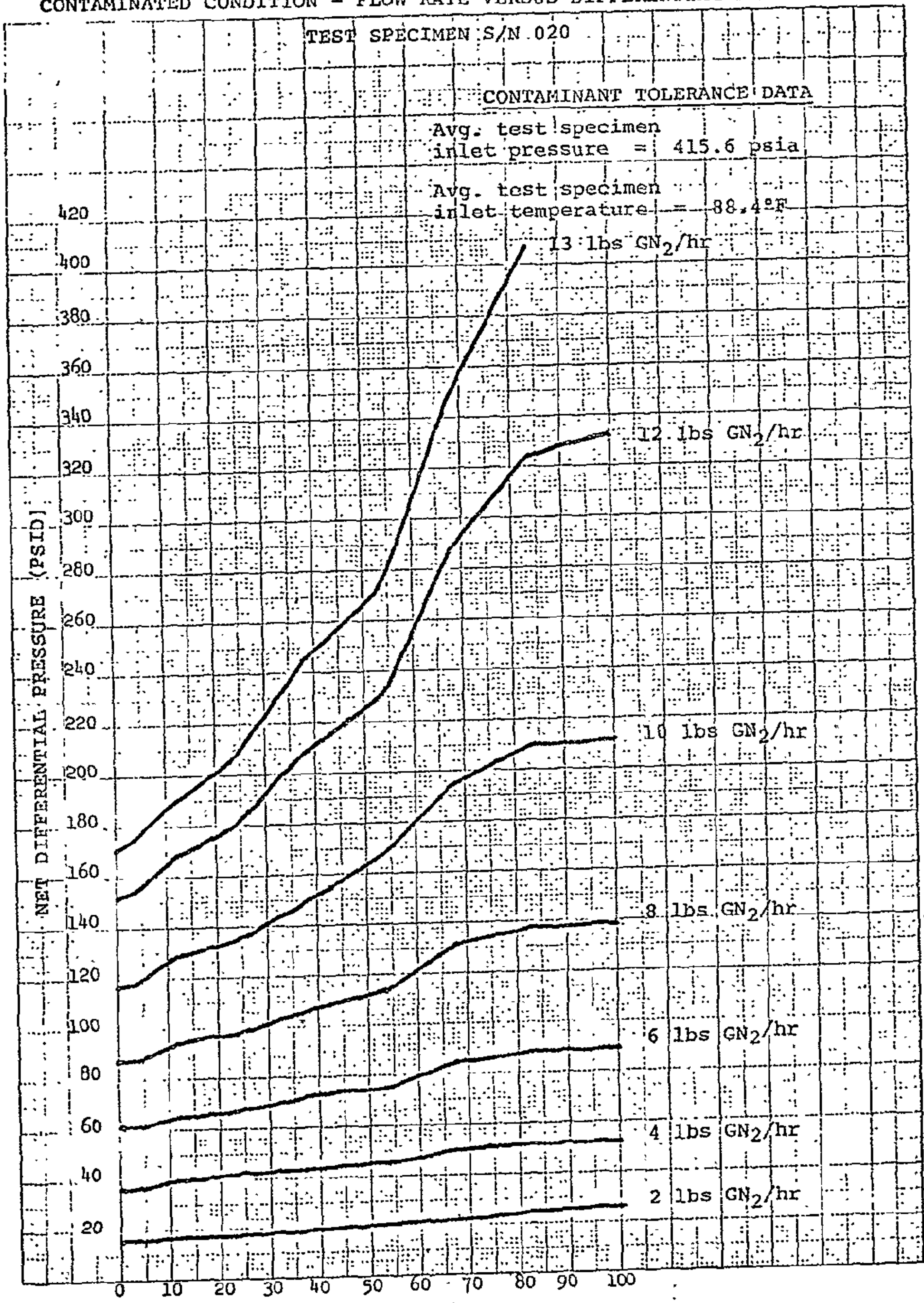
10 X 10 TO THE CENTIMETER 46 1510
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

Figure 35

TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 020



MG Synthetic Contaminant Added

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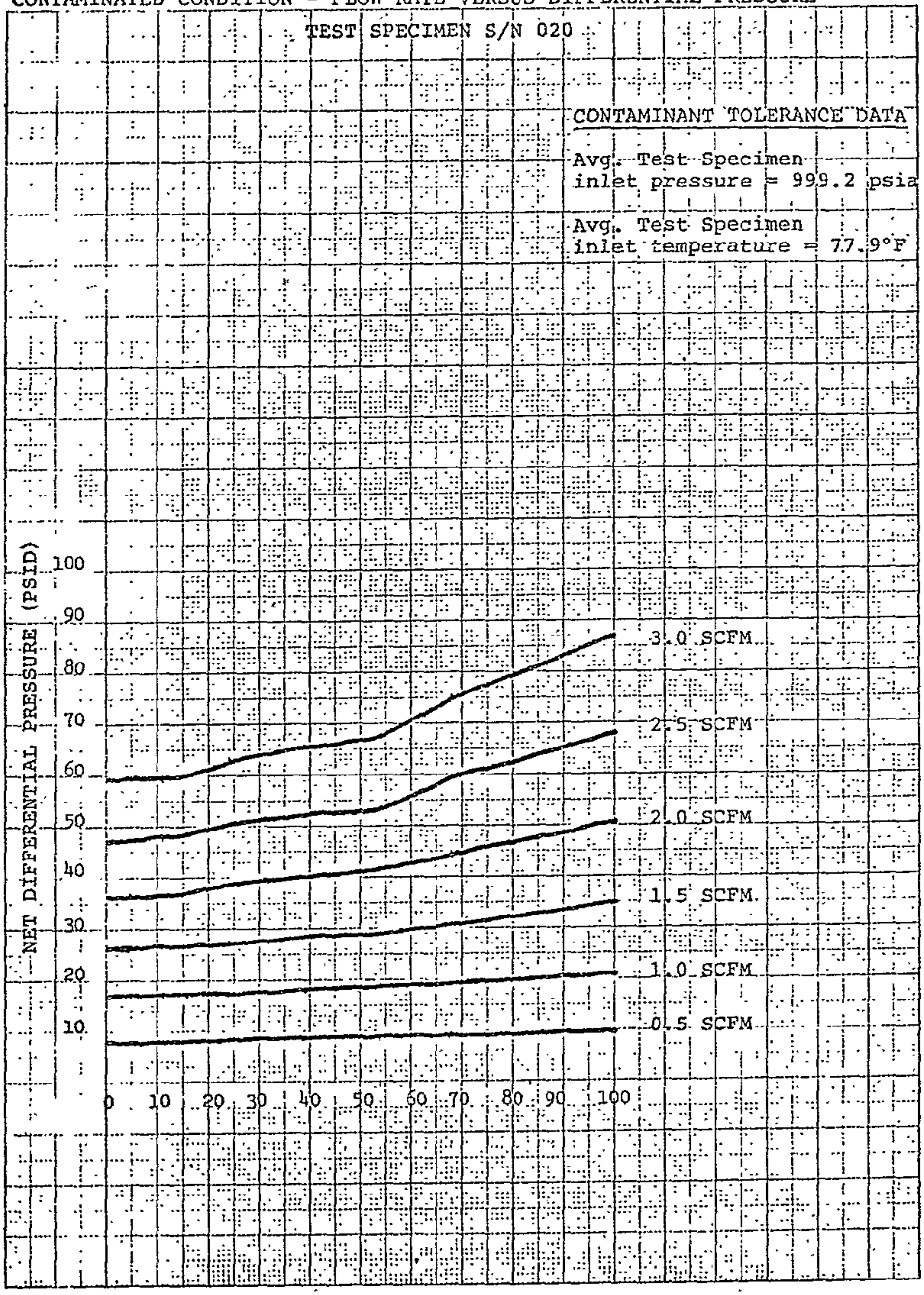
Figure 36

TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE



MG Synthetic Contaminant Added

K+E 10 X 10 TO THE CENTIMETER 18 X 25 CM. KEUFFEL & ESSER CO. 46 1510 MADE IN U.S.A.

Figure 37

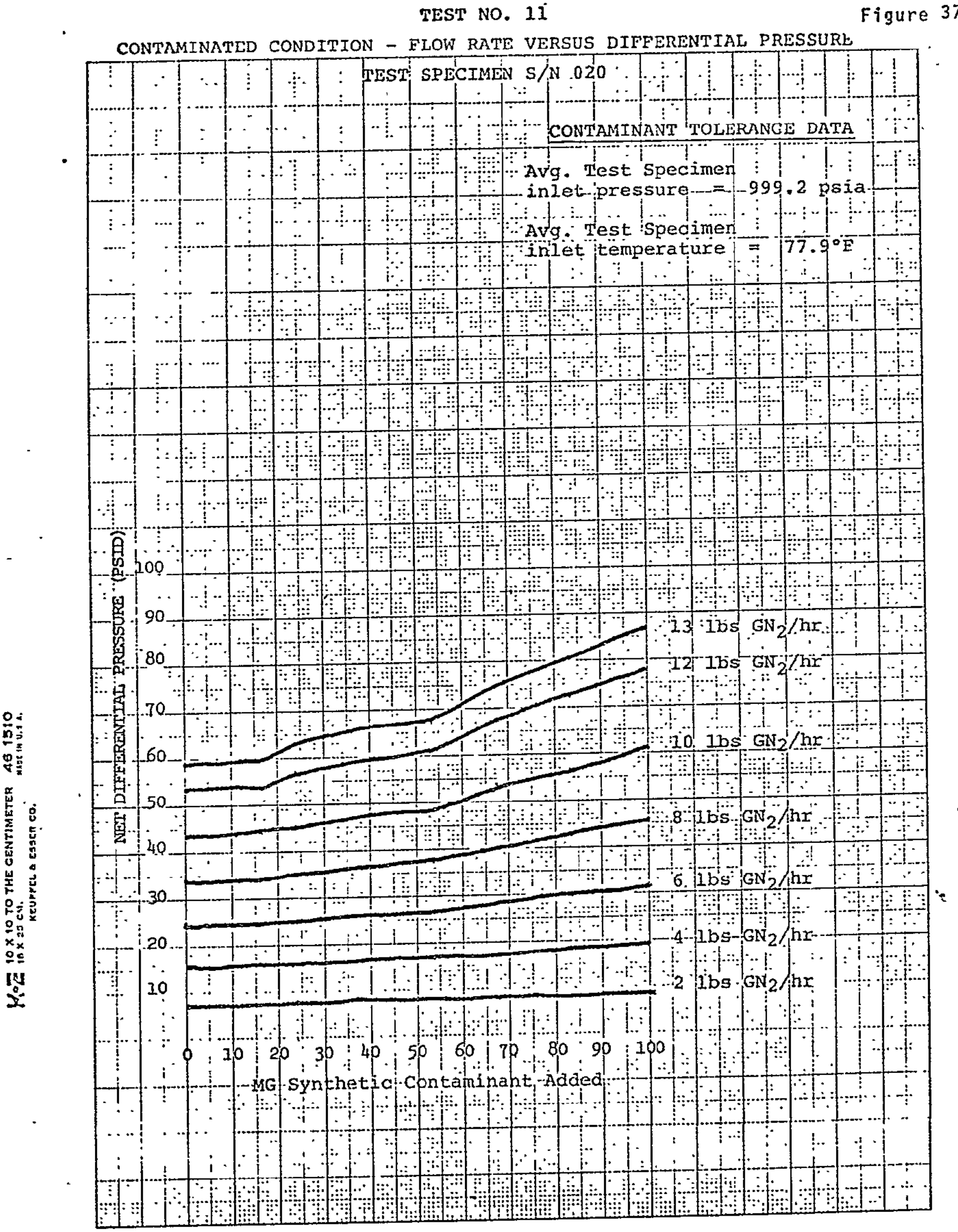

TEST NO. 11
CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
TEST SPECIMEN S/N 020
CONTAMINANT TOLERANCE DATA
Avg. Test Specimen inlet pressure = 999.2 psia
Avg. Test Specimen inlet temperature = 77.9°F
NET DIFFERENTIAL PRESSURE (PSID)
100
90
80
70
60
50
40
30
20
10
13 lbs GN2/hr
12 lbs GN2/hr
10 lbs GN2/hr
8 lbs GN2/hr
6 lbs GN2/hr
4 lbs GN2/hr
2 lbs GN2/hr
0 10 20 30 40 50 60 70 80 90 100
MG Synthetic Contaminant Added
10 X 10 TO THE CENTIMETER 46 1510
KEUFFEL & ESSER CO.

Table XXIII

TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
TEST SPECIMEN S/N 020

NOMINAL TEST SPECIMEN INLET PRESSURE = 29.177 Kg/cm^2

FLOW RATE ($Kg\ GN_2/hr$)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 DIFFERENTIAL)									
	TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)									
	0.0	4.9	11.3	16.7	24.1	38.9	53.9	67.3	83.5	100.2
0.5	0.627	0.600	0.649	0.646	0.606	0.762	0.770	0.871	1.154	1.38[illegible]
1.0	1.399	1.392	1.470	1.466	1.466	1.561	1.577	1.723	1.752	1.75[illegible]
1.5	2.178	2.184	2.309	2.304	2.325	2.484	2.536	2.793	2.863	2.84[illegible]
2.0	2.996	3.011	3.198	3.197	3.229	3.481	3.592	3.985	4.127	4.12[illegible]
2.5	3.873	3.894	4.157	4.169	4.214	4.569	4.759	5.324	5.530	5.54[illegible]
3.0	4.819	4.850	5.199	5.235	5.302	5.779	6.076	6.868	7.144	7.18[illegible]
3.5	5.845	5.890	6.335	6.408	6.511	7.146	7.583	8.690	9.077	9.14[illegible]
4.0	6.958	7.023	7.574	7.698	7.860	8.709	9.332	10.875	11.469	11.58[illegible]
4.5	8.164	8.258	8.924	9.116	9.363	10.512	11.376	13.527	14.500	14.69[illegible]
5.0	9.471	9.603	10.393	10.673	11.037	12.604	13.780	16.771	18.405	18.74[illegible]
5.5	10.884	11.067	11.989	12.378	12.898	15.039	16.619	20.759	23.493	24.10[illegible]
6.0	12.410	12.658	13.719	14.241	14.965	17.882	19.979	25.682	------	-----

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Table XXIII

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (Kg/cm}^2\text{ differential)} = a + b\,(\log \text{Kg } GN_2/\text{hr}) + c\,(\log \text{Kg } GN_2/\text{hr})^2 + d\,(\log \text{Kg } GN_2/\text{hr})^3 + e\,(\log \text{Kg } GN_2/\text{hr})^4$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (PSIA)	AVG. TEST SPECIMEN INLET TEMPERATURE (°F)	EQUATION COEFFICIENTS a	b	c	d	e	SIGMA
0.0	29.190	297.6	0.145693	1.099554	-0.098008	0.322142	--------	0.065
4.9	29.217	296.8	0.143724	1.128544	-0.169942	0.389166	--------	0.036
11.3	28.971	301.0	0.167434	1.119751	-0.096439	0.333083	--------	0.101
16.7	28.920	299.5	0.166075	1.120757	-0.096156	0.368398	--------	0.074
24.1	29.304	299.6	0.166160	1.160662	-0.225818	0.514615	--------	0.067
38.9	29.445	303.5	0.193537	1.127521	0.135895	-0.348465	0.718379	0.067
53.9	29.416	299.8	0.197734	1.149132	0.181647	-0.421566	0.810811	0.073
67.3	29.311	303.5	0.236378	1.158639	0.267813	-0.685100	1.179051	0.049
83.5	29.203	300.9	0.245634	1.119816	0.827164	-2.214470	2.474630	0.116
100.2	29.249	298.2	0.244428	1.054097	1.213296	-2.956009	2.967916	0.100

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TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
TEST SPECIMEN S/N 020

NOMINAL TEST SPECIMEN INLET PRESSURE = 29.177 Kg/cm^2

	NET DIFFERENTIAL PRESSURE (Kg/cm^2 DIFFERENTIAL)									
	TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)									
FLOW RATE liters GN_2/min)*	0.0	4.9	11.3	16.7	24.1	38.9	53.9	67.3	83.5	100.2
10	0.995	0.978	1.030	1.036	1.020	1.134	1.129	1.247	1.322	1.403
15	1.525	1.517	1.598	1.603	1.607	1.702	1.721	1.889	1.926	1.917
20	2.065	2.063	2.180	2.187	2.203	2.348	2.397	2.641	2.706	2.691
25	2.626	2.629	2.788	2.800	2.823	3.038	3.125	3.459	3.566	3.564
30	3.212	3.220	3.426	3.447	3.478	3.766	3.902	4.340	4.487	4.497
35	3.829	3.841	4.101	4.134	4.175	4.535	4.732	5.293	5.481	5.493
40	4.478	4.496	4.814	4.865	4.920	5.356	5.626	6.336	6.570	6.577
45	5.163	5.188	5.570	5.643	5.716	6.239	6.599	7.493	7.789	7.790
50	5.884	5.919	6.369	6.472	6.569	7.198	7.664	8.787	9.175	9.179
55	6.645	6.691	7.215	7.353	7.483	8.247	8.838	10.247	10.774	10.802
60	7.446	7.506	8.109	8.289	8.462	9.402	10.139	11.906	12.641	12.727
65	8.289	8.367	9.054	9.283	9.509	10.679	11.587	13.801	14.838	15.041
70	9.176	9.274	10.051	10.337	10.627	12.096	13.204	15.974	17.443	17.846
75	10.108	10.231	11.102	11.454	11.822	13.673	15.013	18.474	20.548	21.275
80	11.086	11.238	12.208	12.636	13.097	15.434	17.043	21.357	24.256	25.492
85	12.113	12.298	13.373	13.885	14.456	17.403	19.323	24.688	28.733	------
90	13.188	13.412	14.598	15.204	15.902	19.607	21.888	28.544	------	------
95	14.314	14.582	15.884	16.595	17.441	22.078	24.775	------	------	------
100	15.493	15.810	17.234	18.062	19.075	24.852	28.028	------	------	------

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Table XXIV

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log}\,(\text{Kg/cm}^2\ \text{differential}) = a + b\,(\log \text{liters } GN_2/\text{min}) + c\,(\log \text{liters } GN_2/\text{min})^2 + d\,(\log \text{liters } GN_2/\text{min})^3 + e\,(\log \text{liters } GN_2/\text{min})^4$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (PSIA)	AVG. TEST SPECIMEN INLET TEMPERATURE (°F)	EQUATION COEFFICIENTS					SIGMA
			a	b	c	d	e	
0.0	29.190	297.6	-1.412082	1.990013	-0.816113	0.235829	--------	0.059
4.9	29.217	296.8	-1.563501	2.281730	-1.005364	0.277552	--------	0.042
11.3	28.971	301.0	-1.464982	2.113227	-0.889267	0.253998	--------	0.106
16.7	28.920	299.5	-1.472521	2.158996	-0.945149	0.273986	--------	0.070
24.1	29.304	299.6	-1.783665	2.806602	-1.391466	0.377100	--------	0.052
38.9	29.445	303.5	2.576104	-9.429755	11.430694	-5.539606	1.017052	0.055
53.9	29.416	299.8	2.305675	-8.751939	10.795909	-5.276740	0.979755	0.062
67.3	29.311	303.5	3.480150	-12.130055	14.556821	-7.138782	1.327809	0.056
83.5	29.203	300.9	7.340883	-23.157747	26.294913	-12.648582	2.291846	0.127
100.2	29.249	298.2	11.906909	-35.889404	39.487559	-18.674366	3.316252	0.157

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TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
TEST SPECIMEN S/N 020

NOMINAL TEST SPECIMEN INLET PRESSURE = 70.307 Kg/cm^2

FLOW RATE (Kg GN_2/hr)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 DIFFERENTIAL)									
	TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)									
	0.0	4.9	11.3	16.7	24.1	38.9	53.9	67.3	83.5	100.2
0.5	0.286	0.280	0.264	0.278	0.282	0.285	0.287	0.298	0.311	0.322
1.0	0.582	0.571	0.559	0.570	0.581	0.595	0.593	0.627	0.647	0.675
1.5	0.898	0.882	0.873	0.881	0.903	0.930	0.926	0.991	1.022	1.073
2.0	1.230	1.208	1.203	1.211	1.245	1.287	1.285	1.386	1.434	1.513
2.5	1.578	1.547	1.546	1.556	1.605	1.663	1.667	1.808	1.880	1.990
3.0	1.939	1.900	1.900	1.915	1.981	2.057	2.069	2.255	2.356	2.503
3.5	2.313	2.263	2.264	2.287	2.372	2.466	2.491	2.725	2.862	3.049
4.0	2.698	2.638	2.637	2.672	2.777	2.890	2.932	3.217	3.395	3.627
4.5	3.095	3.022	3.018	3.067	3.195	3.328	3.389	3.730	3.956	4.236
5.0	3.503	3.416	3.407	3.474	3.625	3.779	3.864	4.263	4.543	4.875
5.5	3.920	3.819	3.803	3.891	4.067	4.242	4.354	4.815	5.155	5.543
6.0	4.348	4.230	4.206	4.318	4.521	4.718	4.860	5.386	5.792	6.239

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NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log } (Kg/cm^2 \text{ differential}) = a + b\,(\log Kg\ GN_2/hr) + c\,(\log Kg\ GN_2/hr)^2 + d\,(\log Kg\ GN_2/hr)^3 + e\,(\log Kg\ GN_2/hr)^4$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (PSIA)	AVG. TEST SPECIMEN INLET TEMPERATURE (°F)	EQUATION COEFFICIENTS					SIGMA
			a	b	c	d	e	
0.0	68.050	301.9	-0.234785	1.051610	0.090361	---------	---------	0.006
4.9	69.750	299.3	-0.243030	1.055540	0.079310	---------	---------	0.005
11.3	70.461	298.1	-0.252731	1.093923	0.041813	---------	---------	0.014
16.7	69.708	295.0	-0.244481	1.061413	0.088911	---------	---------	0.013
24.1	70.321	299.4	-0.236186	1.072357	0.094065	---------	---------	0.010
38.9	70.043	300.4	-0.225827	1.088116	0.087287	---------	---------	0.014
53.9	70.865	295.2	-0.227238	1.080954	0.120127	---------	---------	0.012
67.3	70.698	300.2	-0.202868	1.109803	0.116467	---------	---------	0.020
83.5	71.283	297.1	-0.189414	1.102934	0.155216	---------	---------	0.019
100.2	71.297	300.1	-0.170778	1.116276	0.160672	---------	---------	0.020

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Table XXVI

TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
TEST SPECIMEN S/N 020

NOMINAL TEST SPECIMEN INLET PRESSURE = 70.307 Kg/cm^2

FLOW RATE (liters GN_2/min)*	NET DIFFERENTIAL PRESSURE (Kg/cm^2 DIFFERENTIAL)									
	TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)									
	0.0	4.9	11.3	16.7	24.1	38.9	53.9	67.3	83.5	100.2
10	0.421	0.409	0.403	0.409	0.417	0.422	0.423	0.440	0.456	0.478
15	0.634	0.619	0.613	0.619	0.633	0.646	0.645	0.682	0.701	0.738
20	0.854	0.836	0.831	0.837	0.858	0.880	0.879	0.939	0.965	1.018
25	1.081	1.060	1.05[illegible]	1.062	1.092	1.125	1.125	1.209	1.245	1.317
30	1.315	1.290	1.286	1.295	1.335	1.378	1.381	1.492	1.540	1.633
35	1.556	1.526	1.522	1.534	1.585	1.640	1.647	1.787	1.850	1.966
40	1.803	1.767	1.764	1.779	1.842	1.909	1.922	2.093	2.174	2.314
45	2.059	2.014	2.010	2.031	2.105	2.185	2.206	2.409	2.512	2.677
50	2.314	2.265	2.261	2.288	2.375	2.468	2.499	2.735	2.863	3.056
55	2.578	2.521	2.517	2.551	2.651	2.758	2.799	3.070	3.226	3.448
60	2.847	2.781	2.776	2.818	2.934	3.054	3.108	3.415	3.602	3.854
65	3.120	3.046	3.040	3.091	3.221	3.356	3.424	3.768	3.990	4.274
70	3.399	3.314	3.307	3.369	3.515	3.664	3.748	4.130	4.389	4.706
75	3.682	3.587	3.578	3.651	3.813	3.978	4.078	4.500	4.800	5.152
80	3.970	3.864	3.853	3.938	4.117	4.297	4.416	4.879	5.222	5.610
85	4.262	4.144	4.131	4.229	4.425	4.621	4.761	5.265	5.655	6.080
90	4.558	4.428	4.412	4.524	4.739	4.950	5.112	5.659	6.098	6.563
95	4.859	4.715	4.697	4.824	5.057	5.285	5.470	6.060	6.553	7.058
100	5.163	5.006	4.984	5.128	5.380	5.624	5.834	6.469	7.017	7.564

*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

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Table XXVI

NOTE: Data values obtained from least square equation of experimental data in the form:

Log (Kg/cm^2 differential) = a + b (log liters GN_2/min) + c (log liters GN_2/min)^2 + d (log liters GN_2/min)^3 + e (log liters GN_2/min)

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (PSIA)	AVG. TEST SPECIMEN INLET TEMPERATURE (°F)	EQUATION COEFFICIENTS a	b	c	d	e	SIGMA
0.0	68.050	301.9	-1.264332	0.789478	0.099574	--------	--------	0.006
4.9	69.750	299.3	-1.312439	0.843088	0.081441	--------	--------	0.006
11.3	70.461	298.1	-1.352331	0.889262	0.067854	--------	--------	0.015
16.7	69.708	295.0	-1.296933	0.814086	0.094678	--------	--------	0.012
24.1	70.321	299.4	-1.295594	0.817375	0.097910	--------	--------	0.013
38.9	70.043	300.4	-1.320316	0.855212	0.089988	--------	--------	0.014
53.9	70.865	295.2	-1.275048	0.781892	0.119301	--------	--------	0.014
67.3	70.698	300.2	-1.308814	0.845249	0.107280	--------	--------	0.020
83.5	71.283	297.1	-1.223663	0.730533	0.152194	--------	--------	0.023
100.2	71.297	300.1	-1.209192	0.733448	0.155265	--------	--------	0.022

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TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 020

NOMINAL TEST SPECIMEN INLET PRESSURE = 415 PSIA

FLOW RATE (SCFM)	NET DIFFERENTIAL PRESSURE (PSID)									
	TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)									
	0.0	4.9	11.3	16.7	24.1	38.9	53.9	67.3	83.5	100.2
0.4	15.265	15.056	15.951	15.898	15.686	17.043	17.123	18.754	19.635	20.18
0.5	19.563	19.461	20.547	20.483	20.473	21.818	22.028	24.072	24.498	24.56
0.6	23.878	23.863	25.180	25.107	25.247	26.835	27.223	29.810	30.279	30.12
0.7	28.242	28.296	29.883	29.808	30.058	32.032	32.640	35.854	36.609	36.38
0.8	32.682	32.793	34.685	34.618	34.949	37.389	38.258	42.159	43.307	43.08
0.9	37.219	37.377	39.606	39.562	39.958	42.906	44.079	48.724	50.294	50.13
1.0	41.870	42.069	44.666	44.661	45.115	48.597	50.119	55.570	57.549	57.47
1.1	46.648	46.887	49.879	49.931	50.445	54.482	56.401	62.731	65.094	65.11
1.2	51.565	51.844	55.258	55.387	55.970	60.587	62.954	70.252	72.974	73.09
1.3	56.631	56.954	60.814	61.044	61.710	66.938	69.810	78.184	81.256	81.48
1.4	61.854	62.228	66.558	66.911	67.683	73.565	77.005	86.585	90.018	90.36
1.5	67.244	67.674	72.498	73.002	73.906	80.499	84.574	95.515	99.351	99.81
1.6	72.807	73.304	78.644	79.325	80.394	87.772	92.557	105.038	109.356	109.95
1.7	78.551	79.126	85.003	85.890	87.163	95.415	100.993	115.226	120.144	120.89
1.8	84.481	85.147	91.584	92.708	94.226	103.465	109.924	126.151	131.837	132.77
1.9	90.604	91.377	98.393	99.788	101.599	111.956	119.396	137.894	144.567	145.73
2.0	96.926	97.821	105.438	107.137	109.295	120.925	129.453	150.540	158.482	159.93
2.1	103.453	104.489	112.727	114.766	117.328	130.411	140.146	164.181	173.746	175.55
2.2	110.190	111.387	120.265	122.683	125.712	140.454	151.525	178.916	190.538	192.80
2.3	117.144	118.522	128.060	130.896	134.462	151.097	163.646	194.851	209.059	211.90
2.4	124.319	125.901	136.120	139.416	143.592	162.383	176.566	212.104	229.533	233.09
2.5	131.721	133.533	144.449	148.250	153.115	174.361	190.346	230.799	252.213	256.67
2.6	139.356	141.423	153.056	157.407	163.047	187.079	205.051	251.072	277.379	282.96
2.7	147.228	149.579	161.948	166.896	173.402	200.590	220.751	273.071	305.349	312.32
2.8	155.345	158.008	171.130	176.726	184.196	214.949	237.518	296.957	336.479	345.17
2.9	163.709	166.717	180.611	186.907	195.443	230.213	255.432	322.906	371.172	381.97
3.0	172.329	175.713	190.396	197.447	207.159	246.446	274.575	351.107	409.881	-------
3.1	181.208	185.004	200.493	208.355	219.361	263.712	295.036	381.758	-------	-------
3.2	190.352	194.597	210.910	219.642	232.063	282.081	316.911	-------	-------	-------
3.3	199.767	204.499	221.652	231.315	245.284	301.627	340.299	-------	-------	-------
3.4	209.459	214.718	232.727	243.386	259.039	322.427	365.310	-------	-------	-------
3.5	219.432	225.261	244.142	255.864	273.346	344.566	392.057	-------	-------	-------

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NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{SCFM}) + c\,(\log \text{SCFM})^2 + d\,(\log \text{SCFM})^3 + e\,(\log \text{SCFM})^4$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (PSIA)	AVG. TEST SPECIMEN INLET TEMPERATURE (°F)	EQUATION COEFFICIENTS					SIGMA
			a	b	c	d	e	
0.0	415.2	76.0	1.621903	1.125428	0.188038	0.319323	---------	0.932
4.9	415.6	74.5	1.623964	1.129680	0.174783	0.387222	---------	0.51[illegible]
11.3	412.1	82.1	1.649378	1.149395	0.197486	0.334420	---------	1.438
16.7	411.3	79.4	1.649325	1.160229	0.228911	0.366846	---------	1.008
24.1	416.8	79.6	1.654319	1.161303	0.227025	0.517629	---------	0.954
33.3	418.8	86.6	1.686309	1.190245	0.199111	0.496878	0.731871	0.957
53.9	418.4	79.9	1.699999	1.228355	0.232890	0.542265	0.784871	0.772
67.3	416.9	86.7	1.744338	1.259015	0.276774	0.699140	1.176255	0.702
83.5	415.4	81.9	1.760040	1.284840	0.152460	0.683694	2.520705	1.636
100.2	416.0	77.1	1.759447	1.302909	0.146386	0.535207	2.972947	1.411

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Table XXVIII

TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 020

NOMINAL TEST SPECIMEN INLET PRESSURE = 415 PSIA

FLOW RATE (lbs GN_2/hr)	NET DIFFERENTIAL PRESSURE (PSID)									
	TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)									
	0.0	4.9	11.3	16.7	24.1	38.9	53.9	67.3	83.5	100.2
1.0	7.897	7.471	8.138	8.097	7.457	9.977	10.117	11.674	17.070	21.857
1.5	12.910	12.630	13.447	13.404	13.063	14.580	14.650	16.117	17.559	18.67
2.0	17.870	17.728	18.738	18.681	18.599	19.908	20.059	21.925	22.436	22.66
2.5	22.832	22.799	24.059	23.986	24.094	25.013	25.936	28.403	23.841	28.72
3.0	27.850	27.900	29.464	29.383	29.622	31.567	32.135	35.312	36.045	35.817
3.5	32.964	33.080	34.995	34.922	35.255	37.733	38.607	42.570	43.746	43.537
4.0	38.209	38.377	40.687	40.640	41.045	44.113	45.351	50.173	51.824	51.70
4.5	43.607	43.822	46.566	46.568	47.040	50.729	52.392	58.156	60.263	60.23
5.0	49.181	49.440	52.655	52.731	53.276	57.615	59.766	66.577	69.107	69.227
5.5	54.945	55.252	58.972	59.151	59.786	64.812	67.519	75.511	78.445	78.69
6.0	60.915	61.275	65.534	65.847	66.597	72.362	75.704	83.039	88.387	88.76
6.5	67.103	67.527	72.354	72.835	73.736	80.313	84.375	95.255	99.070	99.57
7.0	73.521	74.021	79.446	80.132	81.226	88.712	93.592	106.257	110.645	111.29
7.5	80.179	80.770	86.822	87.753	89.091	97.610	103.415	118.151	123.280	124.09
8.0	87.087	87.788	94.495	95.711	97.352	107.059	113.912	131.054	137.165	138.19
8.5	94.254	95.086	102.475	104.022	106.031	117.114	125.150	145.091	152.509	153.81
9.0	101.690	102.676	110.773	112.698	115.150	127.831	137.204	160.396	169.548	171.22
9.5	109.403	110.569	119.400	121.752	124.730	139.272	150.152	177.118	188.544	190.707
10.0	117.402	118.776	128.367	131.200	134.792	151.501	164.077	195.419	209.798	212.607
10.5	125.695	127.308	137.683	141.053	145.358	164.584	179.068	215.474	233.648	237.30
11.0	134.291	136.177	147.360	151.325	156.450	178.593	195.220	237.478	260.478	265.25
11.5	143.197	145.393	157.408	162.031	168.090	193.604	212.636	261.645	290.728	296.947
12.0	152.424	154.967	167.838	173.182	180.301	209.697	231.426	238.208	324.903	332.971
12.5	161.977	164.910	178.659	184.794	193.106	226.961	251.706	317.427	363.578	374.017
13.0	171.867	175.233	189.882	196.880	206.529	245.485	273.605	349.586	407.417	-------
13.5	182.102	185.948	201.518	209.455	220.593	265.369	297.259	385.000	-------	-------
14.0	192.689	197.065	213.577	222.531	235.324	286.718	322.816	-------	-------	-------
14.5	203.638	208.596	226.071	236.125	250.747	309.644	350.433	-------	-------	-------
15.0	214.956	220.552	239.011	250.250	266.887	334.268	380.283	-------	-------	-------

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Table XXVIII

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\mathrm{LOG\ (PSID)} = a + b\,(\log \mathrm{lbs\ GN_2/hr}) + c\,(\log \mathrm{lbs\ GN_2/hr})^2 + d\,(\log \mathrm{lbs\ GN_2/hr})^3 + e\,(\log \mathrm{lbs\ GN_2/hr})^4$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (PSIA)	AVG. TEST SPECIMEN INLET TEMPERATURE (°F)	EQUATION COEFFICIENTS					SIGMA
			a	b	c	d	e	
0.0	415.2	76.0	0.897436	1.277286	-0.425329	0.320281	--------	0.929
4.9	415.6	74.5	0.873360	1.383621	-0.572194	0.389941	--------	0.508
11.3	412.1	82.1	0.910531	1.306138	-0.442554	0.334337	--------	1.444
16.7	411.3	79.4	0.908342	1.314791	-0.471546	0.366346	--------	1.060
24.1	416.8	79.6	0.872592	1.500244	-0.759105	0.515933	--------	0.943
38.9	418.8	86.6	0.999020	0.796623	1.001527	-1.336519	0.719764	0.959
53.9	418.4	79.9	1.005050	0.747466	1.185546	-1.533961	0.810947	0.784
67.3	416.9	86.7	1.067227	0.542729	1.802958	-2.293742	1.176794	0.692
83.5	415.4	81.9	1.232237	-0.621876	4.835068	-5.590354	2.466727	1.638
100.2	416.0	77.1	1.339587	-1.306387	6.362640	-7.039601	2.971339	1.431

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

Table XXIX

TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 020

NOMINAL TEST SPECIMEN INLET PRESSURE = 1,000 PSIA

FLOW RATE (SCFM)	NET DIFFERENTIAL PRESSURE (PSID)									
	TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)									
	0.0	4.9	11.3	16.7	24.1	38.9	53.9	67.3	83.5	100.2
0.4	6.451	6.332	6.238	6.297	6.401	6.533	6.529	6.861	7.088	7.383
0.5	8.142	7.998	7.908	7.963	8.116	8.312	8.287	8.764	9.035	9.434
0.6	9.877	9.704	9.619	9.675	9.882	10.148	10.107	10.745	11.070	11.585
0.7	11.652	11.448	11.369	11.429	11.696	12.037	11.988	12.798	13.190	13.833
0.8	13.465	13.228	13.155	13.224	13.556	13.975	13.924	14.920	15.391	16.173
0.9	15.315	15.041	14.974	15.055	15.458	15.960	15.915	17.108	17.671	18.602
1.0	17.200	16.886	16.824	16.923	17.402	17.988	17.959	19.359	20.026	21.117
1.1	19.117	18.762	18.704	18.826	19.384	20.059	20.052	21.669	22.455	23.715
1.2	21.067	20.667	20.613	20.761	21.404	22.171	22.193	24.038	24.955	26.394
1.3	23.048	22.601	22.549	22.729	23.460	24.321	24.381	26.463	27.525	29.152
1.4	25.059	24.561	24.511	24.727	25.552	26.508	26.615	28.942	30.162	31.988
1.5	27.098	26.548	26.499	26.755	27.677	28.732	28.893	31.475	32.866	34.899
1.6	29.165	28.561	28.511	28.812	29.835	30.991	31.214	34.058	35.635	37.885
1.7	31.260	30.598	30.546	30.897	32.024	33.283	33.577	36.693	38.467	40.943
1.8	33.381	32.659	32.604	33.009	34.245	35.609	35.981	39.376	41.352	44.073
1.9	35.527	34.743	34.684	35.148	36.496	37.967	38.426	42.107	44.318	47.274
2.0	37.699	36.850	36.785	37.313	38.777	40.356	40.909	44.885	47.335	50.544
2.1	39.896	38.979	38.908	39.503	41.086	42.775	43.432	47.709	50.412	53.882
2.2	42.116	41.130	41.050	41.718	43.424	45.225	45.992	50.579	53.547	57.288
2.3	44.361	43.302	43.213	43.957	45.790	47.704	48.589	53.493	56.740	60.761
2.4	46.628	45.495	45.395	46.220	48.182	50.212	51.224	56.450	59.991	64.299
2.5	48.918	47.708	47.596	48.507	50.601	52.747	53.894	59.451	63.298	67.902
2.6	51.230	49.941	49.816	50.816	53.046	55.311	56.599	62.494	66.660	71.570
2.7	53.564	52.194	52.054	53.148	55.517	57.901	59.340	65.578	70.078	75.302
2.8	55.919	54.466	54.309	55.501	58.013	60.518	62.115	68.704	73.551	79.097
2.9	58.295	56.757	56.582	57.877	60.534	63.161	64.925	71.870	77.078	82.954
3.0	60.693	59.066	58.873	60.274	63.080	65.830	67.768	75.077	80.658	86.873
3.1	63.110	61.393	61.180	62.692	65.649	68.524	70.644	78.323	84.292	90.854
3.2	65.548	63.739	63.503	65.131	68.242	71.243	73.552	81.608	87.977	94.895
3.3	68.005	66.102	65.843	67.590	70.889	73.987	76.493	84.931	91.715	98.997
3.4	70.483	68.482	68.199	70.069	73.499	76.755	79.467	88.293	95.505	103.150
3.5	72.979	70.880	70.571	72.568	76.161	79.547	82.471	91.692	99.316	107.380

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NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{SCFM}) + c\,(\log \text{SCFM})^2 + d\,(\log \text{SCFM})^3 + e\,(\log \text{SCFM})^4$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (PSIA)	AVG. TEST SPECIMEN INLET TEMPERATURE (°F)	EQUATION COEFFICIENTS a	b	c	d	e	SIGMA
0.0	967.9	83.7	1.235518	1.105521	0.088513	--------	--------	0.088
4.9	992.1	79.1	1.227533	1.101979	0.079187	--------	--------	0.069
11.3	1002.2	77.0	1.225931	1.108886	0.065494	--------	--------	0.182
16.7	991.5	71.4	1.228485	1.114101	0.088215	--------	--------	0.186
24.1	1000.2	79.2	1.240587	1.128190	0.092337	--------	--------	0.148
38.9	996.2	80.9	1.254993	1.139738	0.086261	--------	--------	0.201
53.9	1007.9	71.8	1.254271	1.151759	0.119581	--------	--------	0.168
67.3	1005.6	80.6	1.286673	1.178286	0.116179	--------	--------	0.287
83.5	1013.9	75.1	1.301593	1.194694	0.153908	--------	--------	0.272
100.2	1014.1	80.5	1.324622	1.210830	0.160562	--------	--------	0.295

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Table XXX

TEST NO 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
TEST SPECIMEN S/N 020

NOMINAL TEST SPECIMEN INLET PRESSURE = 1,000 PSIA

FLOW RATE (lbs GN_2/hr)	NET DIFFERENTIAL PRESSURE (PSID)									
	TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)									
	0.0	4.9	11.3	16.7	24.1	38.9	53.9	67.3	83.5	100.2
1.0	3.694	3.609	3.515	3.581	3.629	3.662	3.703	3.826	4.009	4.150
1.5	5.555	5.445	5.350	5.409	5.498	5.591	5.600	5.857	6.073	6.312
2.0	7.478	7.340	7.249	7.304	7.442	7.607	7.588	8.004	8.263	8.618
2.5	9.459	9.289	9.205	9.260	9.456	9.700	9.662	10.257	10.574	11.060
3.0	11.494	11.290	11.213	11.273	11.535	11.865	11.816	12.608	12.999	13.630
3.5	13.580	13.339	13.268	13.339	13.675	14.095	14.045	15.051	15.532	16.324
4.0	15.715	15.432	15.368	15.456	15.871	16.387	16.347	17.581	18.169	19.135
4.5	17.896	17.567	17.508	17.619	18.121	18.738	18.717	20.193	20.906	22.060
5.0	20.120	19.743	19.688	19.828	20.423	21.143	21.152	22.884	23.740	25.094
5.5	22.386	21.956	21.905	22.079	22.774	23.601	23.651	25.651	26.667	28.234
6.0	24.693	24.206	24.158	24.372	25.171	26.109	26.210	28.491	29.684	31.477
6.5	27.038	26.492	26.444	26.704	27.614	28.666	28.829	31.401	32.791	34.822
7.0	29.420	28.811	28.762	29.075	30.101	31.269	31.505	34.380	35.983	38.265
7.5	31.838	31.164	31.111	31.483	32.631	33.917	34.236	37.425	39.260	41.804
8.0	34.292	33.547	33.491	33.926	35.201	36.609	37.022	40.536	42.620	45.438
8.5	36.780	35.962	35.899	36.405	37.811	39.343	39.861	43.709	46.061	49.164
9.0	39.301	38.407	38.336	38.917	40.461	42.119	42.751	46.944	49.582	52.983
9.5	41.854	40.880	40.800	41.463	43.148	44.934	45.692	50.240	53.181	56.891
10.0	44.438	43.382	43.291	44.040	45.872	47.789	48.683	53.594	56.857	60.887
10.5	47.054	45.912	45.807	46.650	48.633	50.681	51.722	57.007	60.610	64.971
11.0	49.700	48.468	48.349	49.290	51.429	53.611	54.809	60.477	64.437	69.141
11.5	52.375	51.051	50.915	51.960	54.260	56.578	57.943	64.002	68.339	------
12.0	55.079	53.660	53.505	54.659	57.124	59.580	61.123	67.583	------	------
12.5	57.812	56.295	56.118	57.387	60.022	62.617	64.349	------	------	------
13.0	60.572	58.954	58.755	60.144	62.953	65.689	67.619	------	------	------
13.5	63.360	61.637	61.414	62.929	65.916	68.795	------	------	------	------
14.0	66.175	64.344	64.095	65.741	68.911	------	------	------	------	------
14.5	69.016	67.075	66.798	68.580	------	------	------	------	------	------
15.0	71.883	69.829	69.522	------	------	------	------	------	------	------

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NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{lbs } GN_2/hr) + c\,(\log \text{lbs } GN_2/hr)^2 + d\,(\log \text{lbs } GN_2/hr)^3 + e\,(\log \text{lbs } GN_2/hr)^4$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (PSIA)	AVG. TEST SPECIMEN INLET TEMPERATURE (°F)	EQUATION COEFFICIENTS					SIGMA
			a	b	c	d	e	
0.0	967.9	83.7	0.567535	0.990176	0.090048	--------	--------	0.089
4.9	992.1	79.1	0.557415	0.999920	0.079977	--------	--------	0.073
11.3	1002.2	77.0	0.545938	1.024280	0.066177	--------	--------	0.183
16.7	991.5	71.4	0.553991	1.001935	0.087926	--------	--------	0.183
24.1	1000.2	79.2	0.559837	1.007692	0.094022	--------	--------	0.147
38.9	996.2	80.9	0.563674	1.028605	0.087045	--------	--------	0.201
53.9	1007.9	71.8	0.568830	0.999010	0.119836	--------	--------	0.168
67.3	1005.6	80.6	0.582699	1.030071	0.116350	--------	--------	0.283
83.5	1013.9	75.1	0.603032	0.996845	0.154908	--------	--------	0.267
100.2	1014.1	80.5	0.618068	1.005710	0.160748	--------	--------	0.293

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Figure 38

HPOF PROGRAM TEST NO. 6

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 023

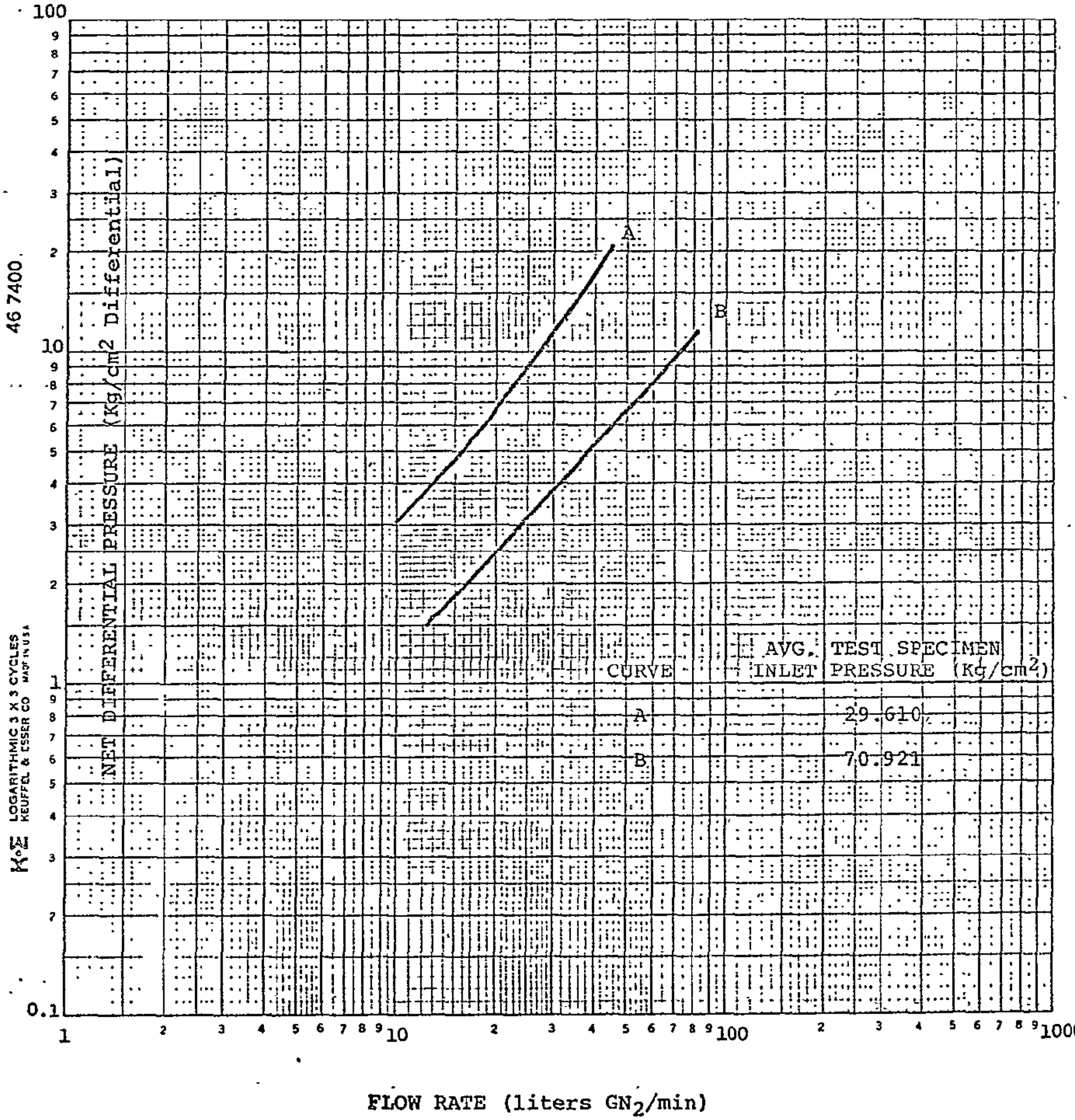


Figure 39

HPOF PROGRAM TEST NO. 6

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 023

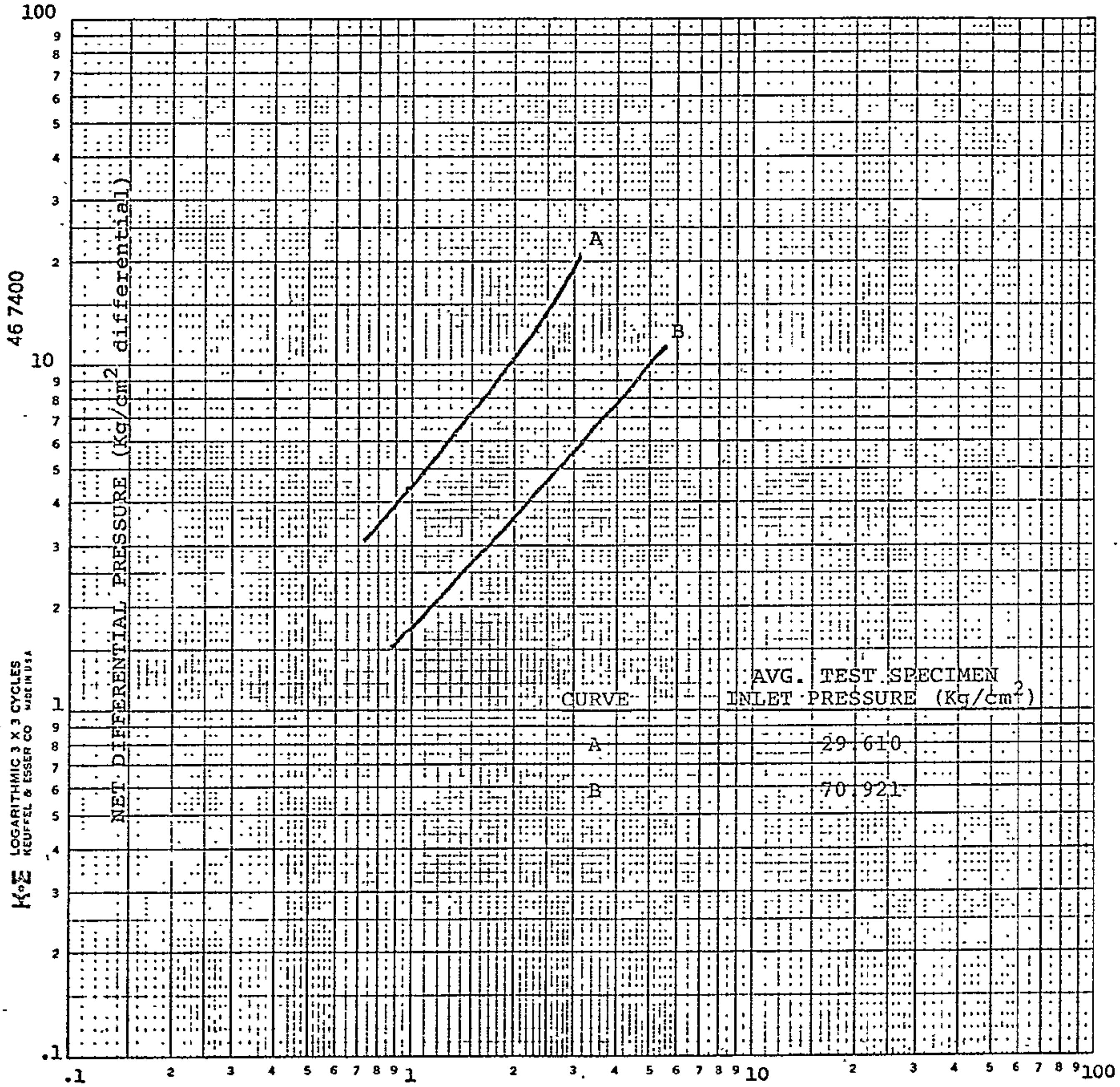
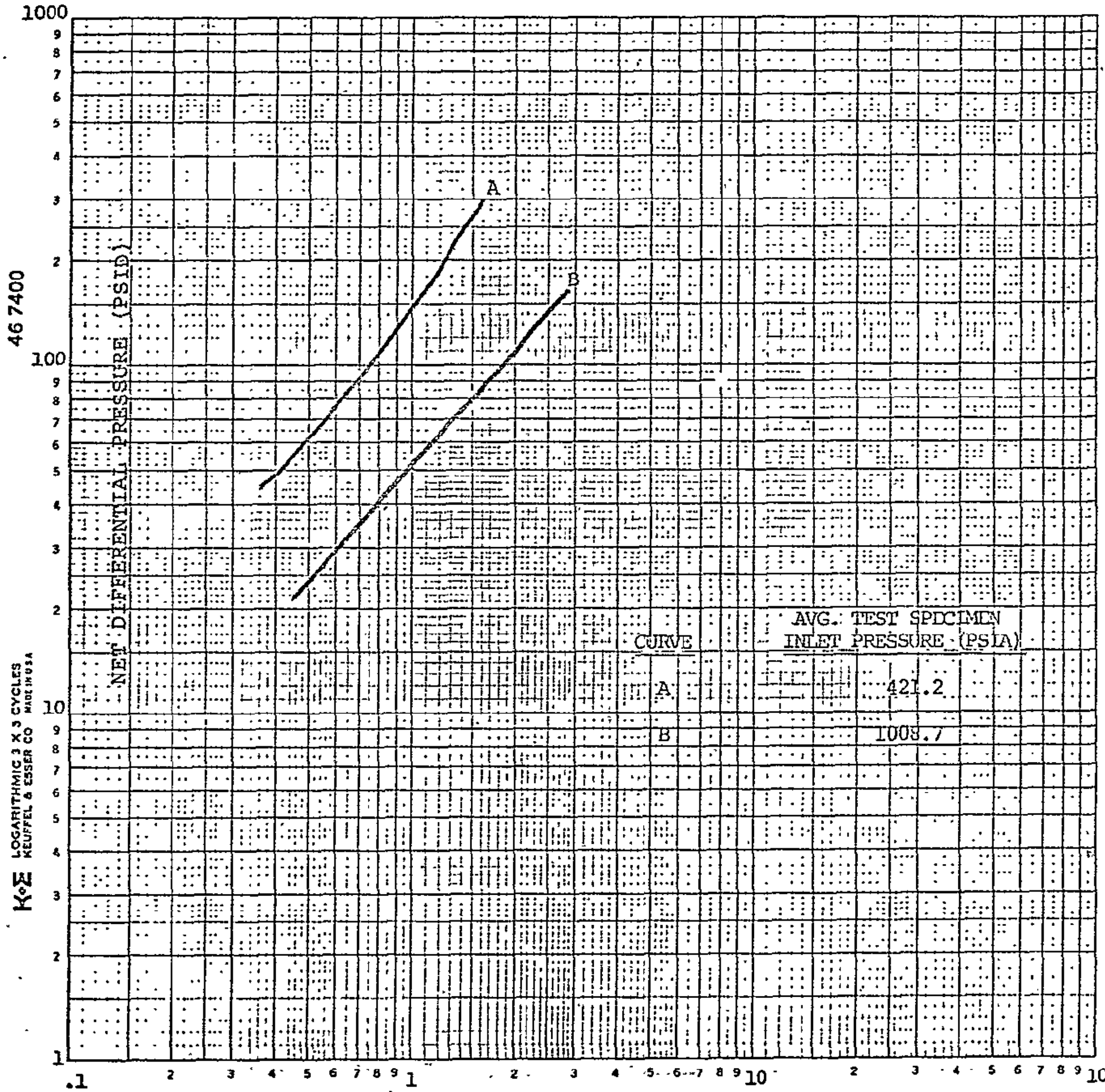


Figure 40

HPOF PROGRAM TEST NO. 6

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 023



FLOW RATE (SCFM)

Figure 41

HPOF PROGRAM TEST NO. 6
CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
TEST SPECIMEN S/N 023

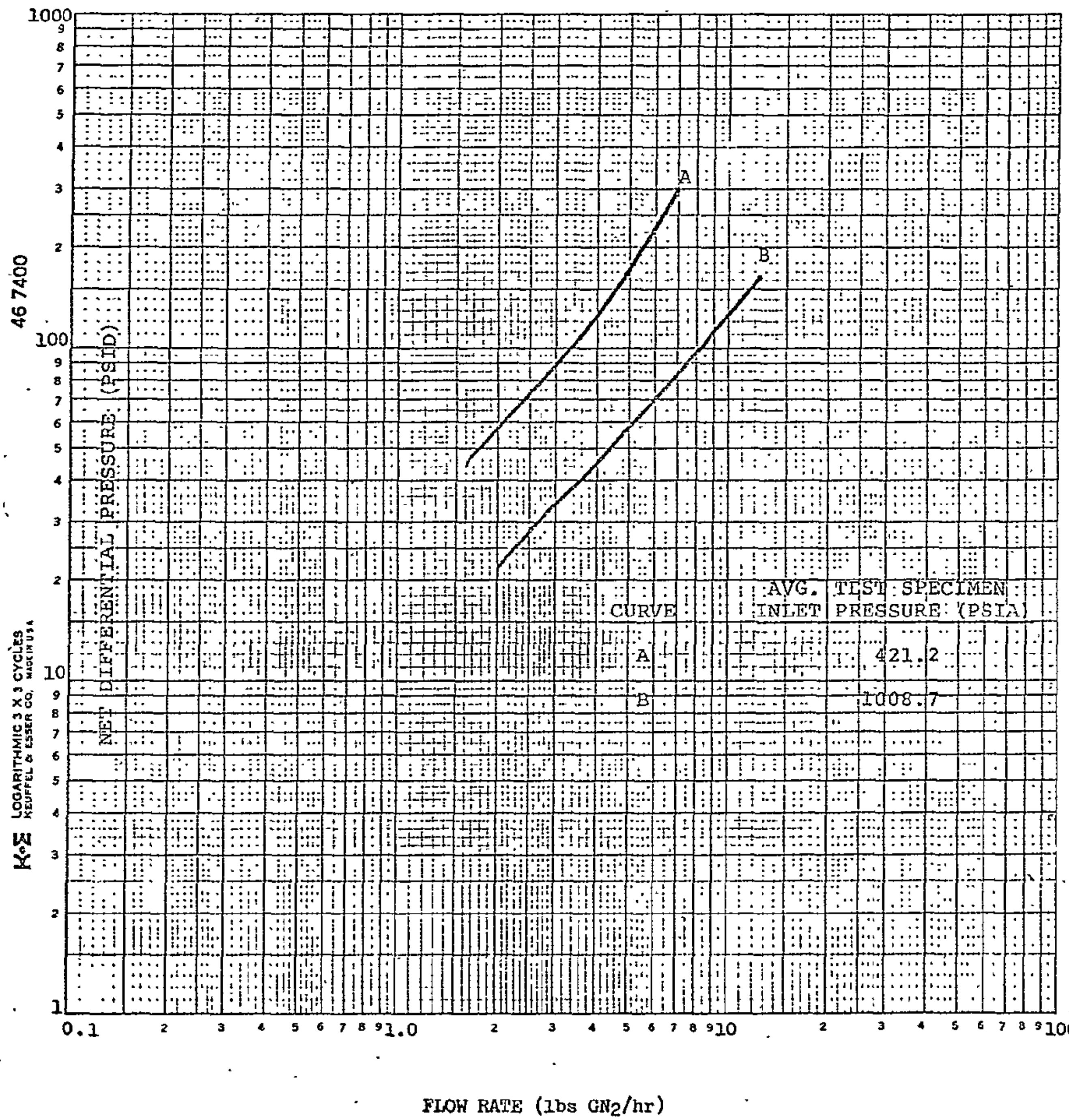


Table XXXI

TEST NO. 6

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE (liters* GN_2/min)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential) — TEST SPECIMEN INLET PRESSURE (Kg/sq cm) 29.610[A]	70.921[B]
10	3.064	1.215
15	4.633	1.811
20	6.381	2.428
25	8.419	3.064
30	10.827	3.719
35	13.685	4.392
40	17.070	5.082
45	21.071	5.788
50	25.783	6.510
55	------	7.248
60	------	8.000
65	------	8.766
70	------	9.546
75	------	10.340
80	------	11.146
85	------	11.965
90	------	12.797
95	------	13.641
100	------	14.497

*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log } (\text{Kg/cm}^2 \text{ differential}) = a + b\ (\text{log liters } GN_2/\text{min}) + c\ (\text{log liters } GN_2/\text{min})^2 + d\ (\text{log liters } GN_2/\text{min})^3$$

A. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = -1.211933 + 3.076583\ (\text{log liters } GN_2/\text{min}) - 2.059819\ (\text{log liters } GN_2/\text{min})^2 + 0.681454\ (\text{log liters } GN_2/\text{min})^3$

Sigma = 0.153

B. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = -0.767541 + 0.740120\ (\text{log liters } GN_2/\text{min}) + 0.112142\ (\text{log liters } GN_2/\text{min})^2$

Sigma = 0.037

Table XXXI

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

Table XXXII

TEST NO. 6

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE ($Kg\ GN_2/hr$)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential) — TEST SPECIMEN INLET PRESSURE (Kg/sq cm) 29.610[A]	70.921[B]
0.5	1.966	0.867
1.0	4.350	1.711
1.5	6.908	2.607
2.0	10.076	3.549
2.5	14.156	4.536
3.0	19.450	5.564
3.5	------	6.631
4.0	------	7.734
4.5	------	8.871
5.0	------	10.042
5.5	------	11.245
6.0	------	12.478

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (Kg/cm}^2\text{ differential)} = a + b\,(\log \text{Kg GN}_2/\text{hr}) + c\,(\log \text{Kg GN}_2/\text{hr})^2 + d\,(\log \text{Kg GN}_2/\text{hr})^3$$

A. $$\text{Log (Kg/cm}^2\text{ differential)} = 0.638519 + 1.091342\,(\log \text{Kg GN}_2/\text{hr}) + 0.109010\,(\log \text{Kg GN}_2/\text{hr})^2 + 0.965732\,(\log \text{Kg GN}_2/\text{hr})^3$$

Sigma + 0.140

B. $$\text{Log (Kg/cm}^2\text{ differential)} = 0.233329 + 1.016985\,(\log \text{Kg GN}_2/\text{hr}) + 0.117993\,(\log \text{Kg GN}_2/\text{hr})^2$$

Sigma = 0.043

Table XXXII

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

Table XXXIII

TEST NO. 6

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE (SCFM)	NET DIFFERENTIAL PRESSURE (PSID) TEST SPECIMEN INLET PRESSURE (PSIA) 421.2[A]	1008.7[B]
0.4	47.724	19.145
0.5	60.865	23.954
0.6	74.417	28.876
0.7	88.813	33.909
0.8	104.391	39.049
0.9	121.434	44.292
1.0	140.199	49.636
1.1	160.936	55.078
1.2	183.897	60.614
1.3	209.343	66.242
1.4	237.548	71.959
1.5	268.804	77.764
1.6	303.421	83.654
1.7	341.735	89.628
1.8	384.105	95.683
1.9	-------	101.818
2.0	-------	108.031
2.1	-------	114.321
2.2	-------	120.686
2.3	-------	127.126
2.4	-------	133.639
2.5	-------	140.223
2.6	-------	146.878
2.7	-------	153.603
2.8	-------	160.396
2.9	-------	167.257
3.0	-------	174.185
3.1	-------	181.178
3.2	-------	188.237
3.3	-------	195.360
3.4	-------	202.547
3.5	-------	209.797

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NOTE: Data values obtained from least square equation of experimental data in the form:

$$\mathrm{Log}\ (\mathrm{PSID}) = a + b\ (\log \mathrm{SCFM}) + c\ (\log \mathrm{SCFM})^2 + d\ (\log \mathrm{SCFM})^3$$

A. $\mathrm{Log}\ (\mathrm{PSID}) = 2.146744 + 1.405828\ (\log \mathrm{SCFM}) + 0.962659\ (\log \mathrm{SCFM})^2 + 0.968242\ (\log \mathrm{SCFM})^3$

Sigma = 2.040

B. $\mathrm{Log}\ (\mathrm{PSID}) = 1.695798 + 1.086543\ (\log \mathrm{SCFM}) + 0.117723\ (\log \mathrm{SCFM})^2$

Sigma = 0.607

Table XXXIII

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

Table XXXIV

TEST NO. 6

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE (lbs GN_2/hr)	NET DIFFERENTIAL PRESSURE (PSID) TEST SPECIMEN INLET PRESSURE (PSIA) 421.2[A]	1008.7[B]
1.0	24.532	11.246
1.5	40.491	16.577
2.0	55.656	22.054
2.5	71.070	27.683
3.0	87.475	33.458
3.5	105.404	39.376
4.0	125.296	45.432
4.5	147.541	51.620
5.0	172.523	57.936
5.5	200.633	64.375
6.0	232.279	70.935
6.5	267.901	77.611
7.0	307.972	84.400
7.5	353.006	91.299
8.0	403.563	98.306
8.5	-------	105.418
9.0	-------	112.633
9.5	-------	119.949
10.0	-------	127.363
10.5	-------	134.873
11.0	-------	142.479
11.5	-------	150.178
12.0	-------	157.969
12.5	-------	165.850
13.0	-------	173.820
13.5	-------	181.878
14.0	-------	190.021
14.5	-------	198.250
15.0	-------	206.563

Table XXXIV

TEST NO. 6

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE (lbs GN_2/hr)	NET DIFFERENTIAL PRESSURE (PSID) TEST SPECIMEN INLET PRESSURE (PSIA)	
	421.2[A]	1008.7[B]
1.0	24.532	11.246
1.5	40.491	16.577
2.0	55.656	22.054
2.5	71.070	27.683
3.0	87.475	33.458
3.5	105.404	39.376
4.0	125.296	45.432
4.5	147.541	51.620
5.0	172.523	57.936
5.5	200.633	64.375
6.0	232.279	70.935
6.5	267.901	77.611
7.0	307.972	84.400
7.5	353.006	91.299
8.0	403.563	98.306
8.5	-------	105.418
9.0	-------	112.633
9.5	-------	119.949
10.0	-------	127.363
10.5	-------	134.873
11.0	-------	142.479
11.5	-------	150.178
12.0	-------	157.969
12.5	-------	165.850
13.0	-------	173.820
13.5	-------	181.878
14.0	-------	190.021
14.5	-------	198.250
15.0	-------	206.563

Table XXXIV

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{lbs } GN_2/\text{hr}) + c\,(\log \text{lbs } GN_2/\text{hr})^2 + d\,(\log \text{lbs } GN_2/\text{hr})^3$$

A. $\text{Log (PSID)} = 1.389733 + 1.363379\,(\log \text{lbs } GN_2/\text{hr}) - 0.895227\,(\log \text{lbs } GN_2/\text{hr})^2 + 0.970825\,(\log \text{lbs } GN_2/\text{hr})^3$

Sigma = 1.995

B. $\text{Log (PSID)} = 1.050982 + 0.936239\,(\log \text{lbs } GN_2/\text{hr}) + 0.117821\,(\log \text{lbs } GN_2/\text{hr})^2$

Sigma = 0.613

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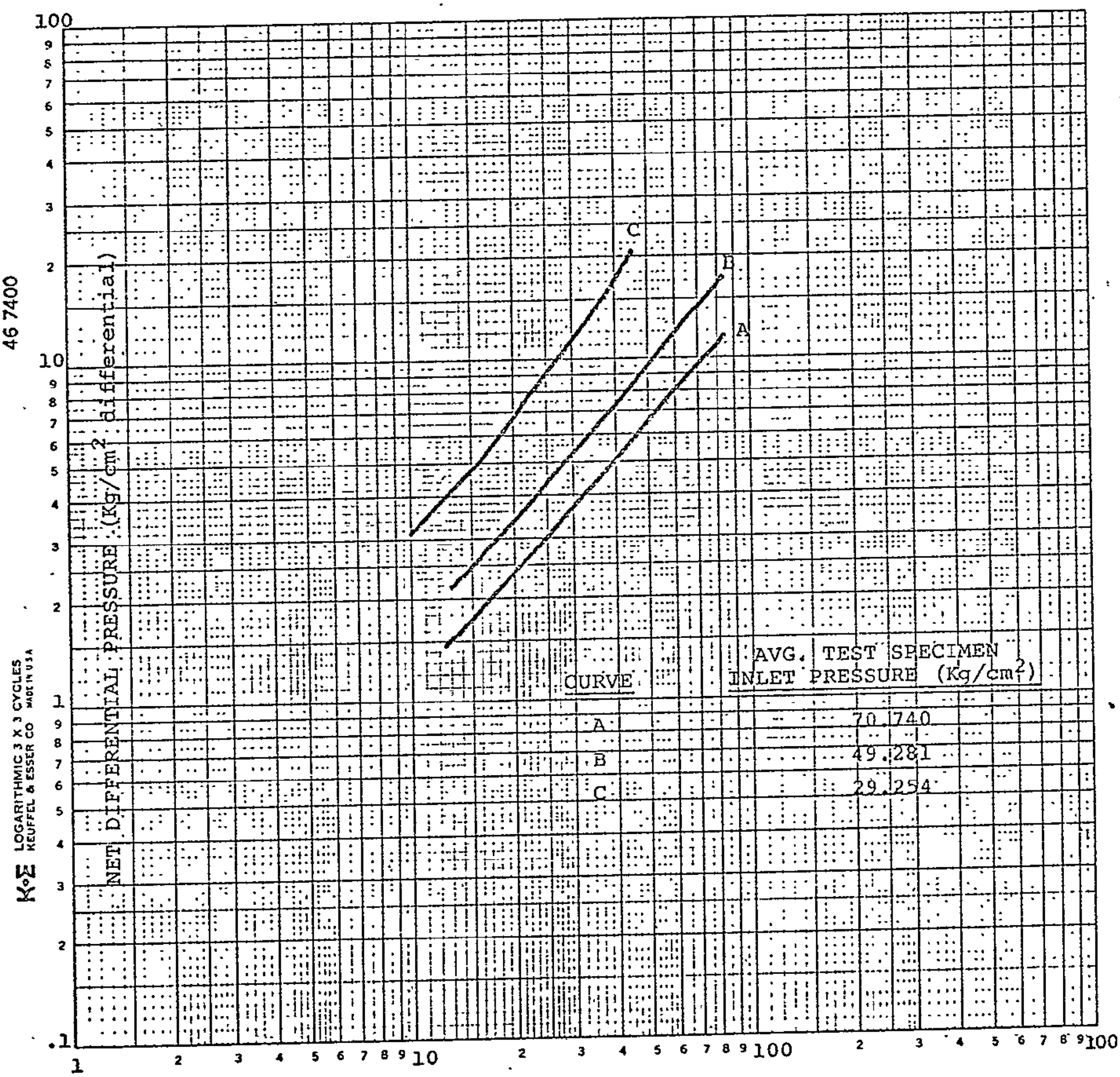
Figure 42

TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 024

Prior to Impact Data



FLOW RATE (liters* GN_2/min)

*At 21.1°C (70°F) and 1.033 (Kg/cm^2 (14.7 psia)

Figure 43

TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 024

Prior to Impact Data

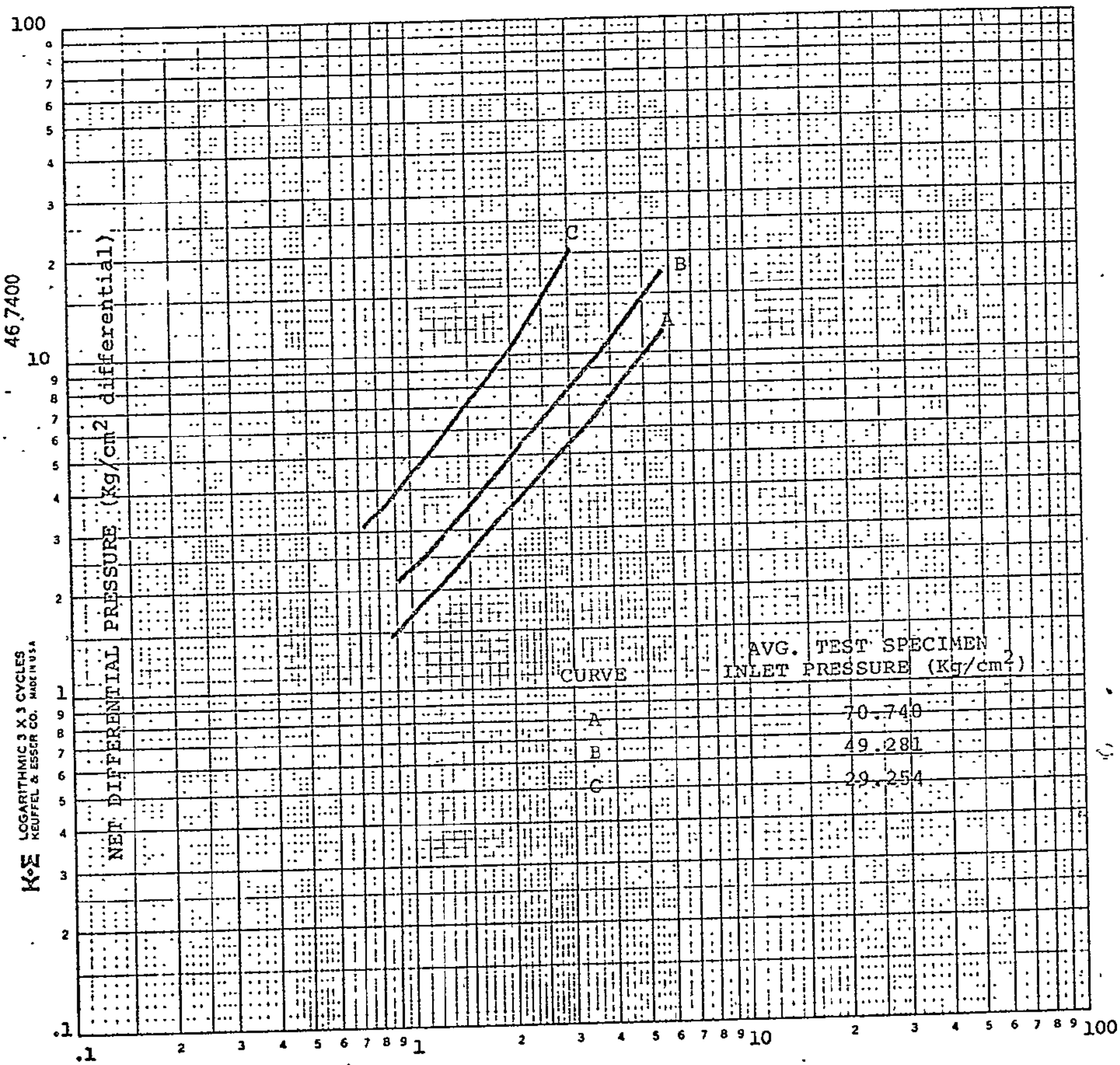


Figure 44

TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 024

Prior to Impact Data

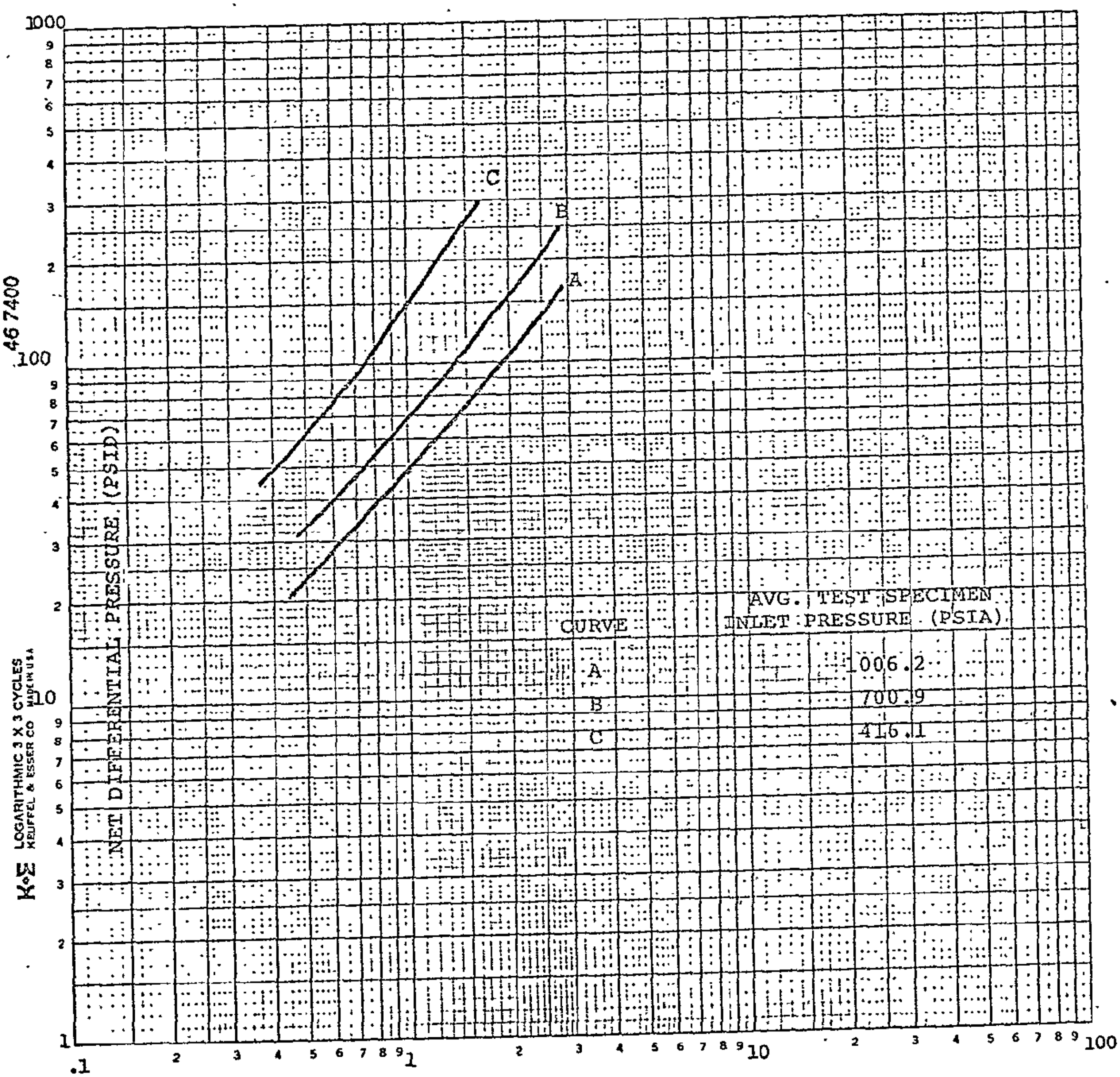


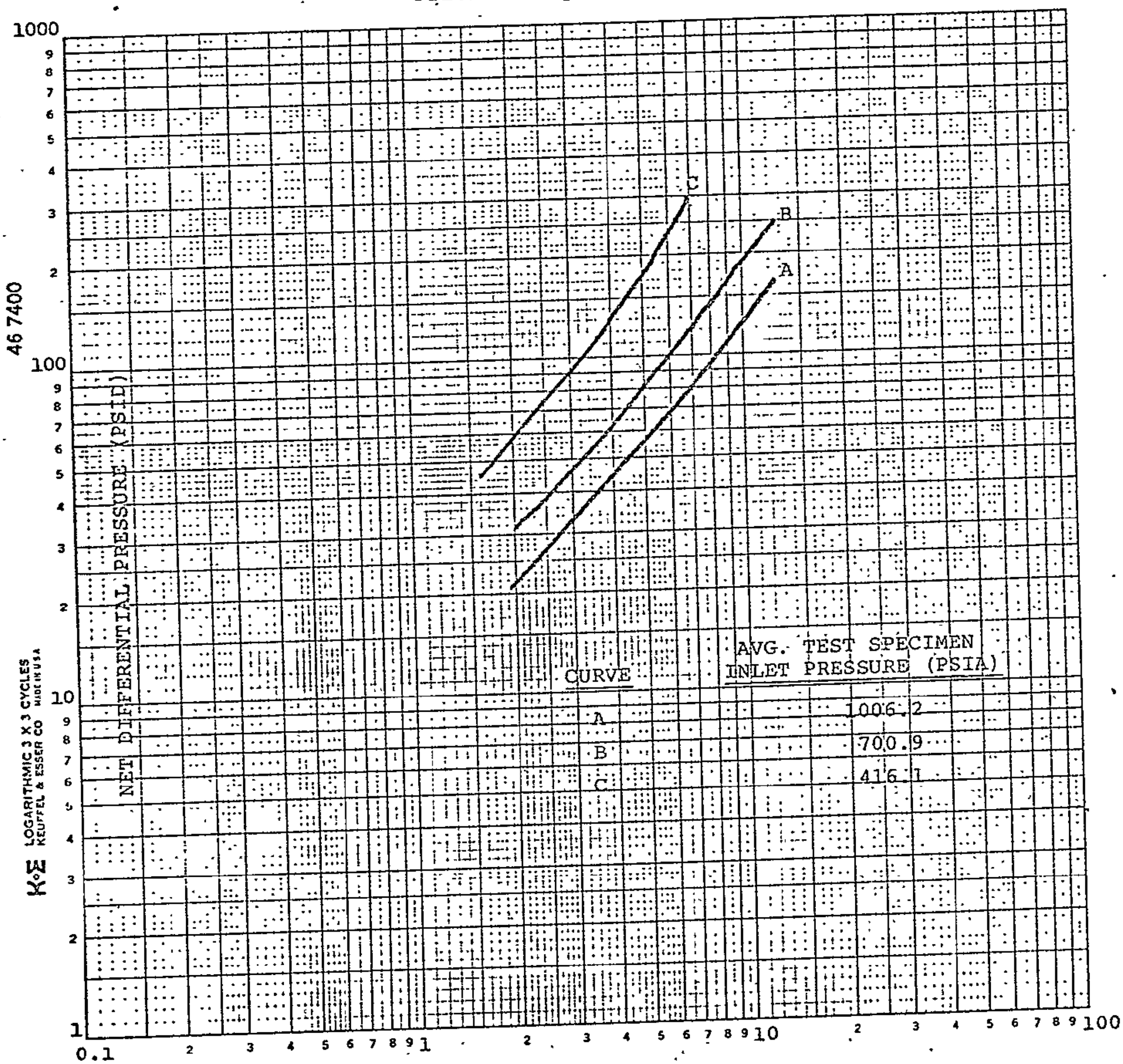
Figure 45

TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 024

Prior to Impact Data



FLOW RATE (lbs/hr)

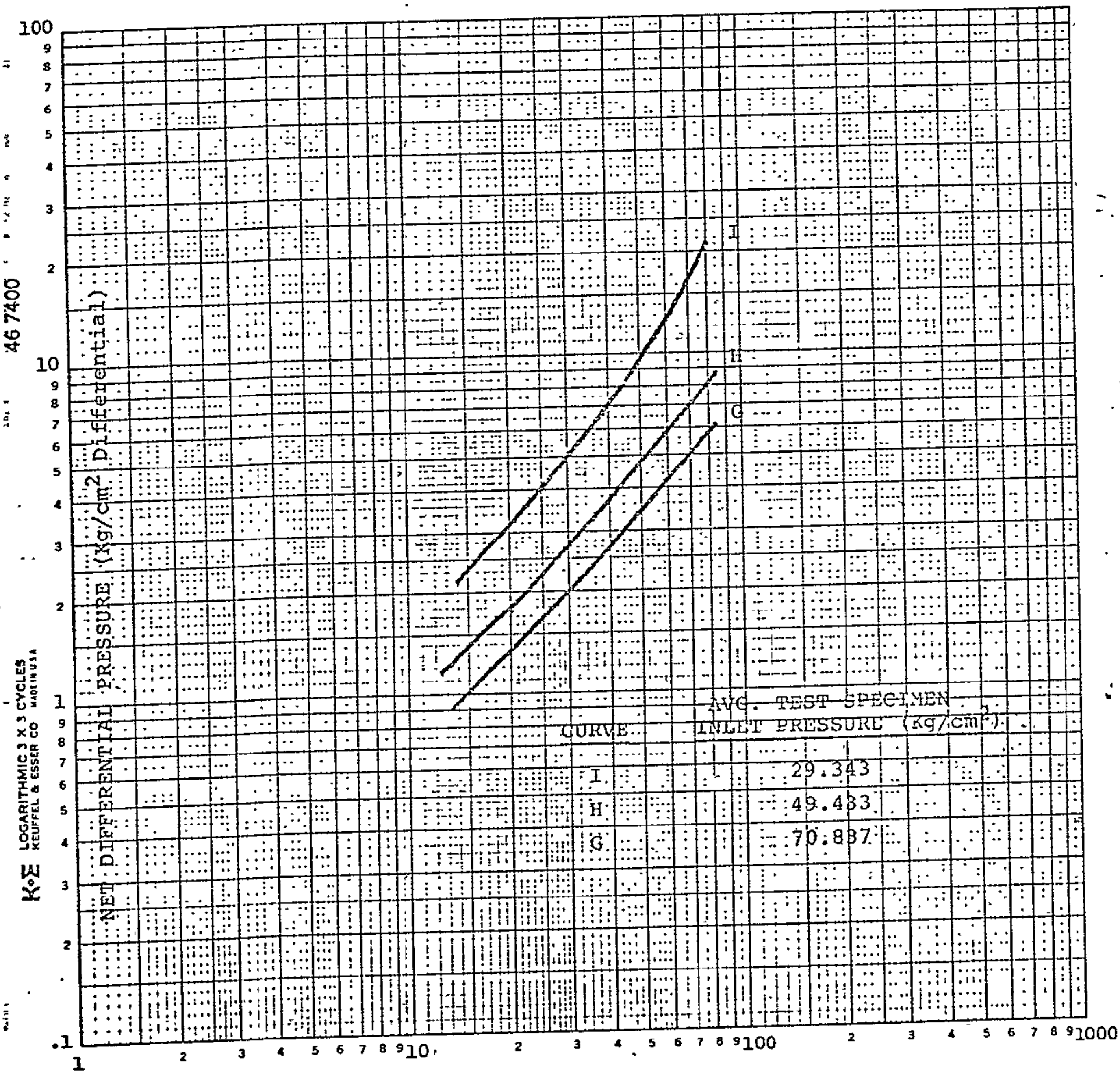
Figure 46

TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 024

DATA AFTER 80 HIGH PRESSURE (703.7 Kg/cm^2 NOMINAL) GN_2 IMPACTS



FLOW RATE (Liters* GN_2/min)

*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

Figure 47

TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 024

DATA AFTER 80 HIGH PRESSURE (703.07 Kg/cm^2 NOMINAL) GN_2 IMPACTS

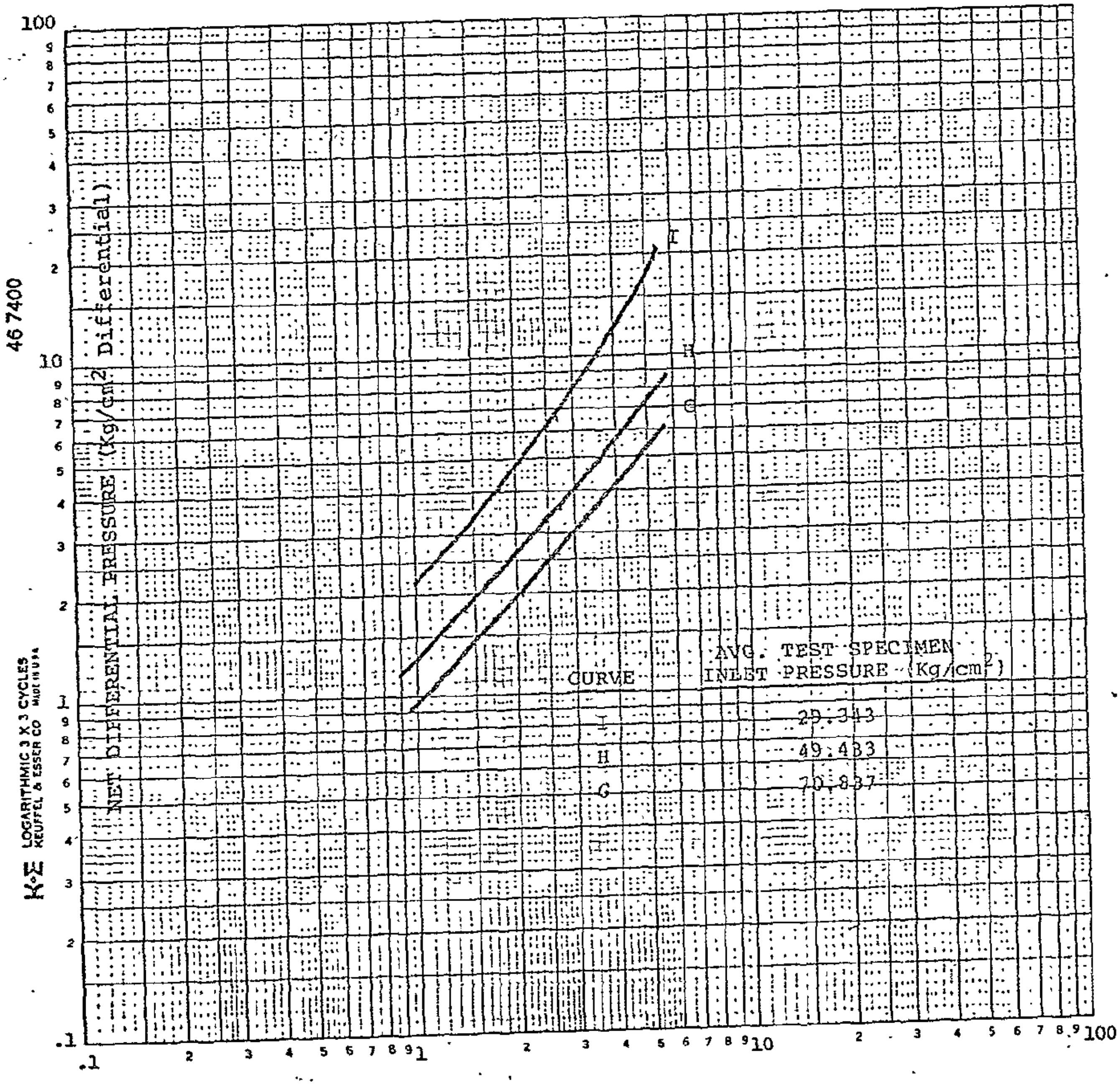


Figure 48

TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 024

DATA AFTER 80 HIGH PRESSURE (10,000 PSIA NOMINAL) GN_2 IMPACTS

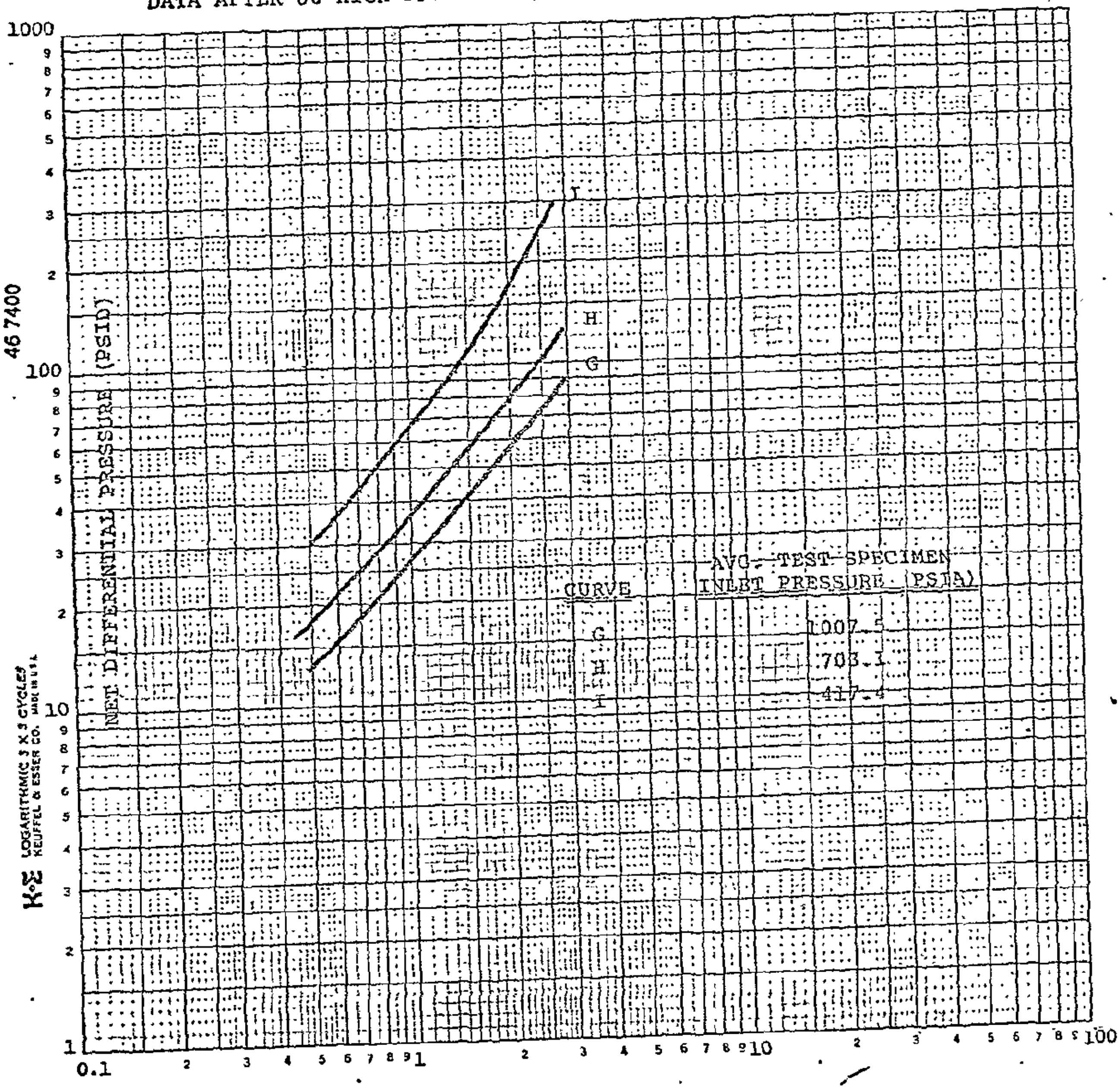


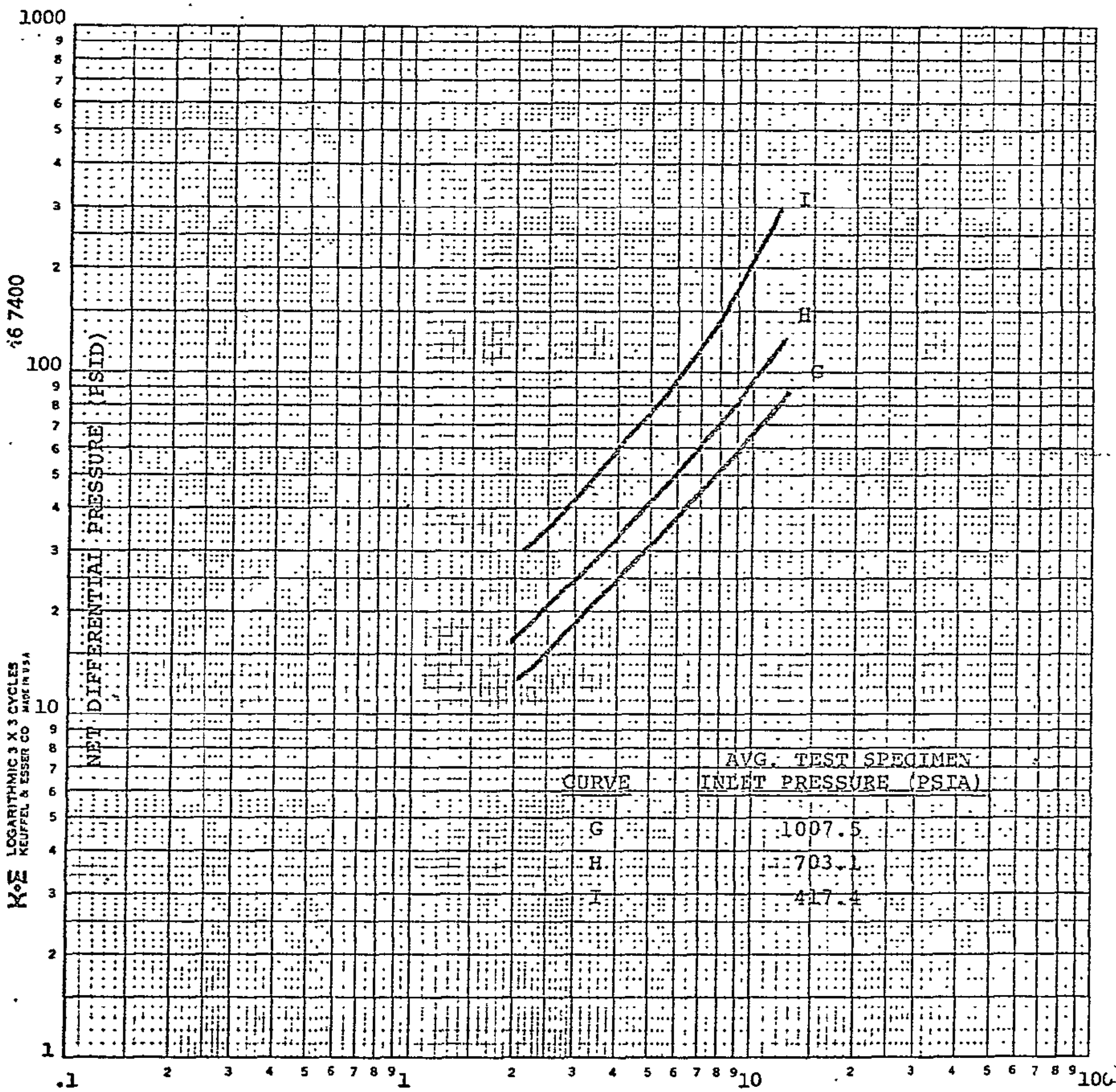
Figure 49

TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 024

DATA AFTER 80 HIGH PRESSURE (10,000 PSIA NOMINAL) GN_2 IMPACTS



FLOW RATE (lbs GN_2/hr)

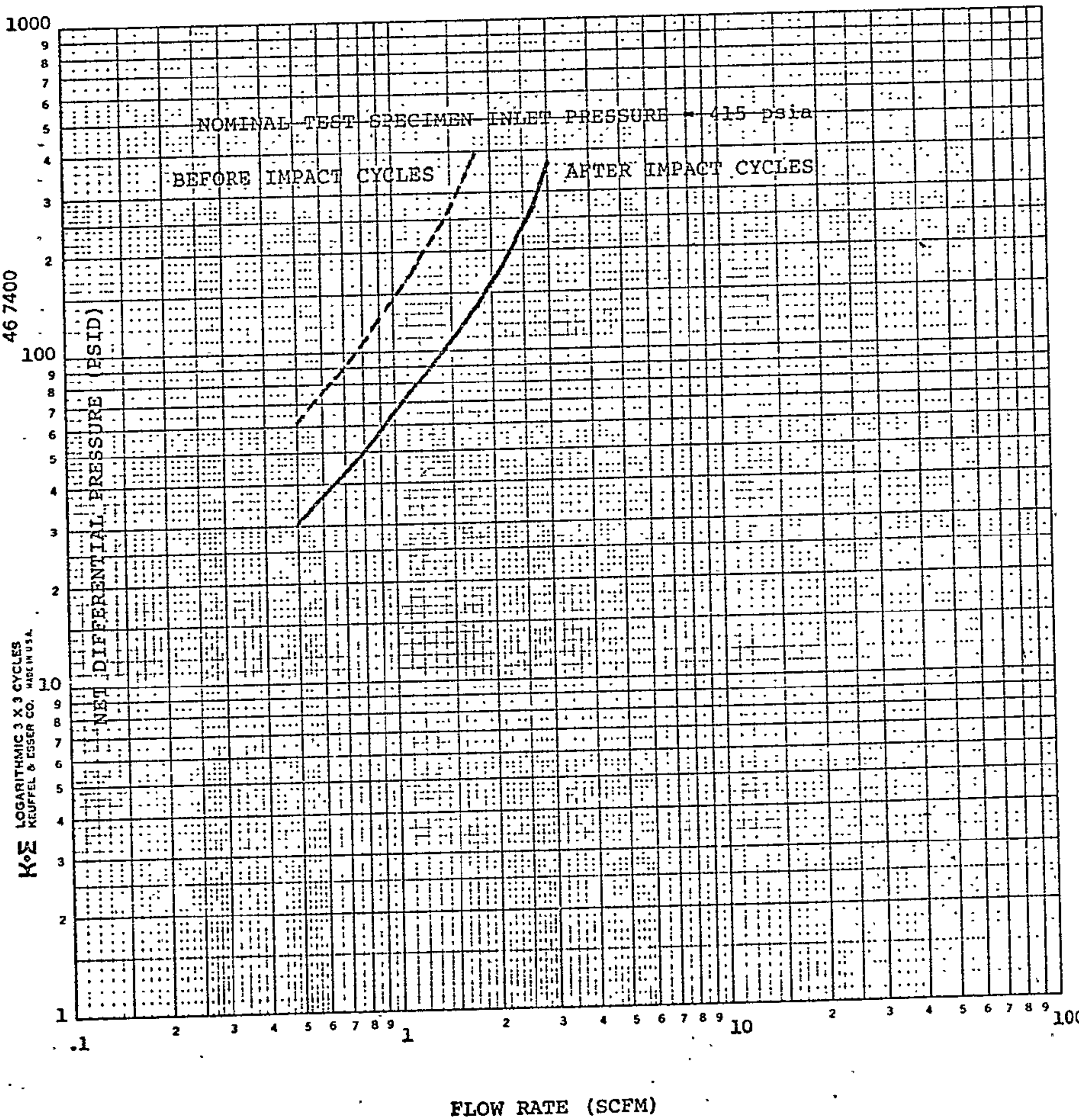
Figure 50

TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

USING SPECIMEN S/N 024 WHICH WAS NOT PROOF-PRESSURE-TESTED

INFLUENCE OF 80 HIGH PRESSURE (10,000 PSIA [703.07 Kg/cm^2] NOMINAL GN_2 IMPACT CYCLES ON THE FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF THE TEST SPECIMEN

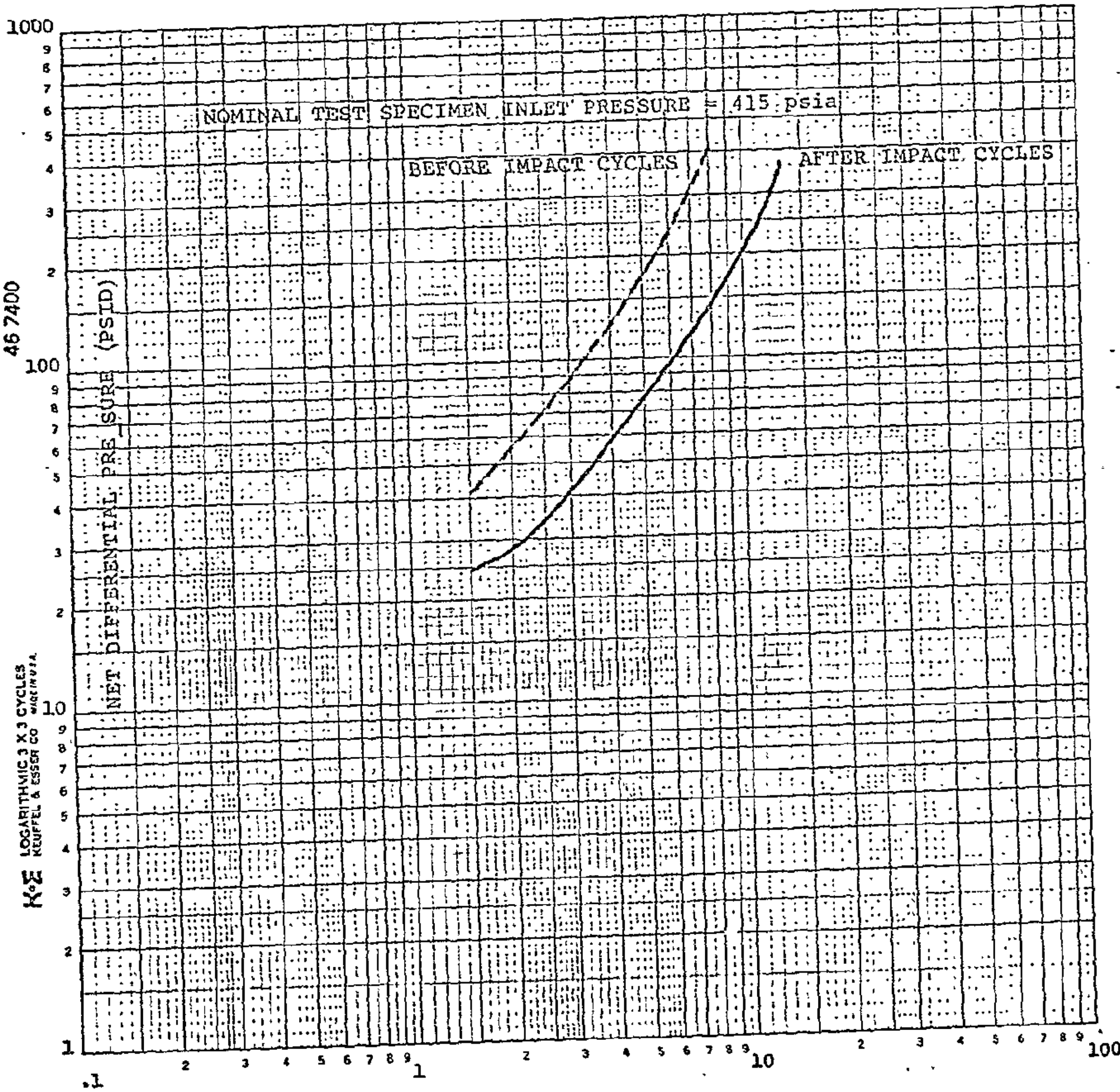


TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

USING SPECIMEN S/N 024 WHICH WAS NOT PROOF-PRESSURE-TESTED

INFLUENCE OF 80 HIGH PRESSURE (10,000 PSIA [703.07 Kg/cm^2] NOMINAL GN_2 IMPACT CYCLES ON THE FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF THE TEST SPECIMEN



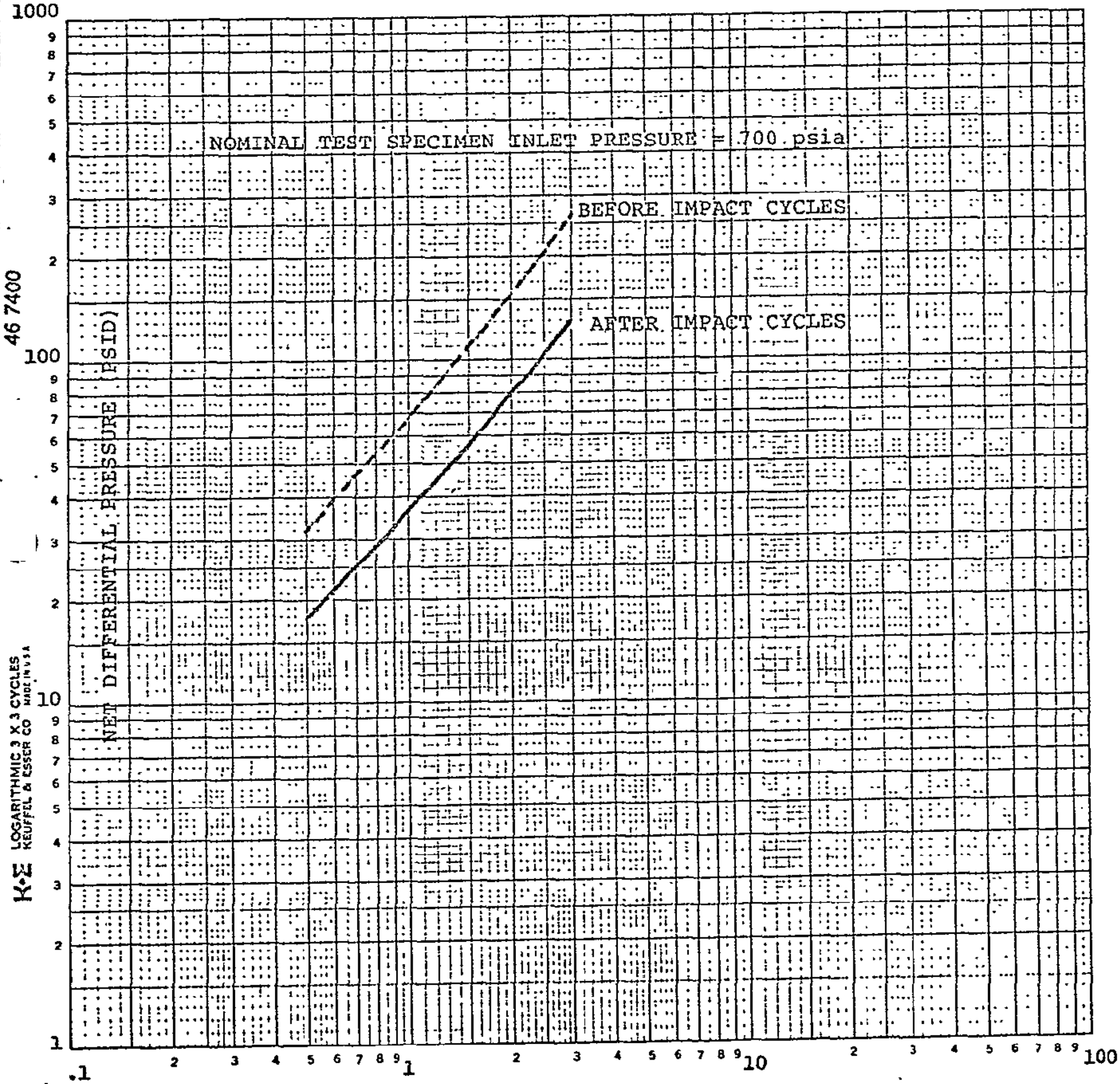
FLOW RATE (lbs GN_2/hr)

Figure 52

TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE USING SPECIMEN S/N 024 WHICH WAS NOT PROOF-PRESSURE-TESTED

INFLUENCE OF 80 HIGH PRESSURE (10,000 PSIA [703.07 Kg/cm^2] NOMINAL GN_2 IMPACT CYCLES ON THE FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF THE TEST SPECIMEN



FLOW RATE (SCFM)

TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

USING SPECIMEN S/N 024 WHICH WAS NOT PROOF-PRESSURE-TESTED

INFLUENCE OF 80 HIGH PRESSURE (10,000 PSIA [703.07 Kg/cm^2] NOMINAL GN_2 IMPACT CYCLES ON THE FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF THE TEST SPECIMEN

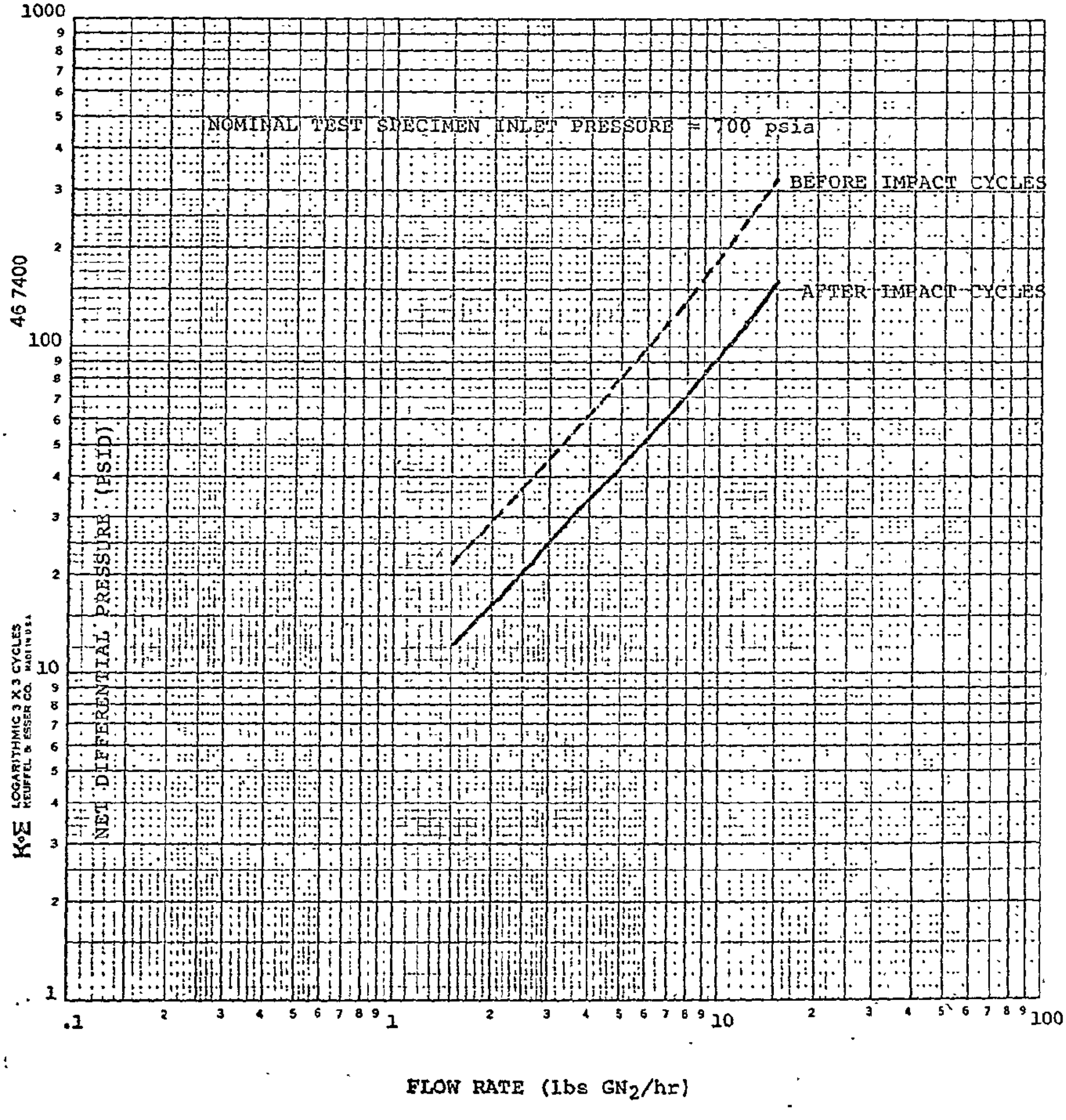


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Figure 54

TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

USING SPECIMEN S/N 024 WHICH WAS NOT PROOF-PRESSURE-TESTED

INFLUENCE OF 80 HIGH PRESSURE (10,000 PSIA [703.07 Kg/cm^2] NOMINAL GN_2 IMPACT CYCLES ON THE FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF THE TEST SPECIMEN

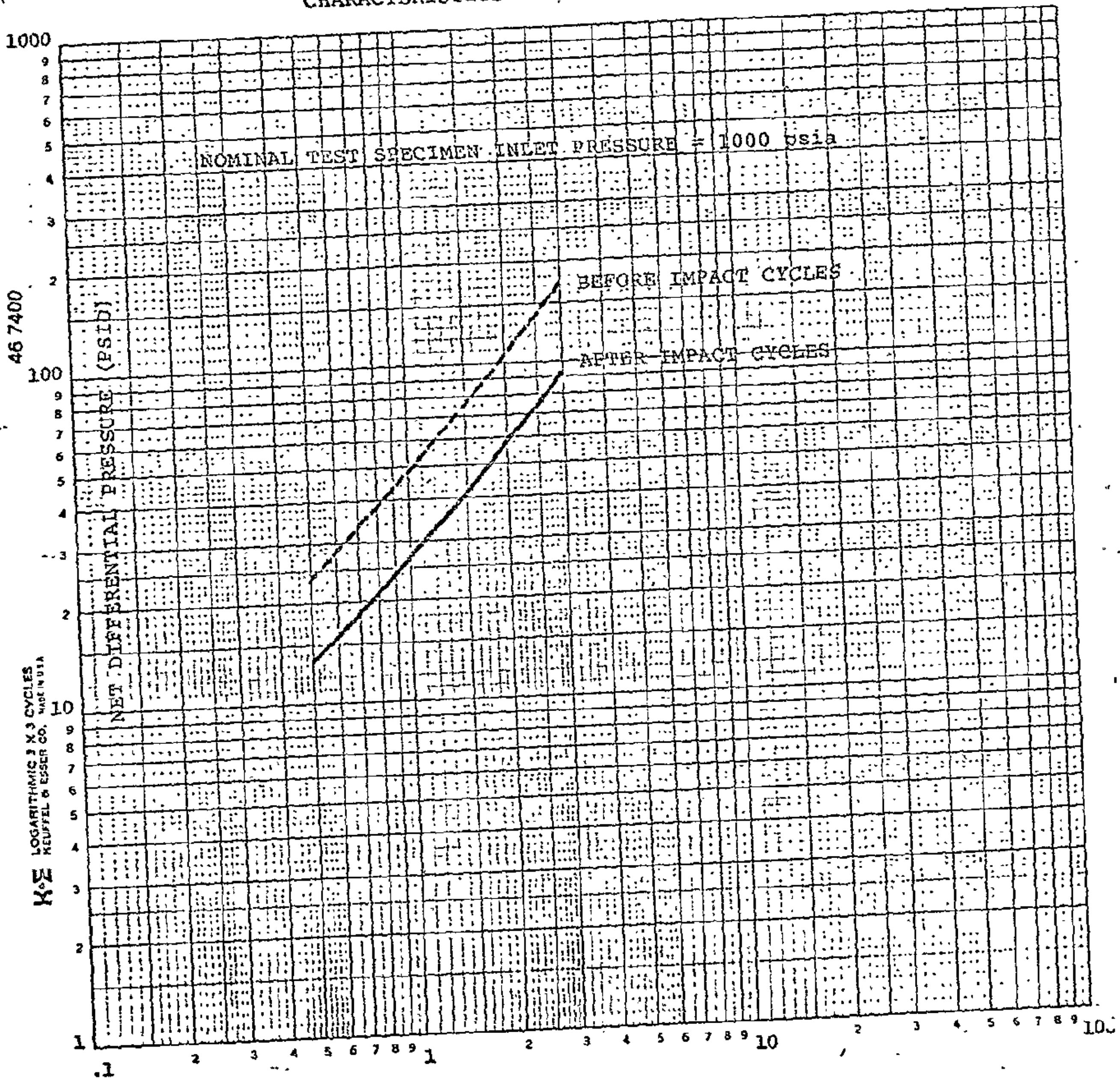

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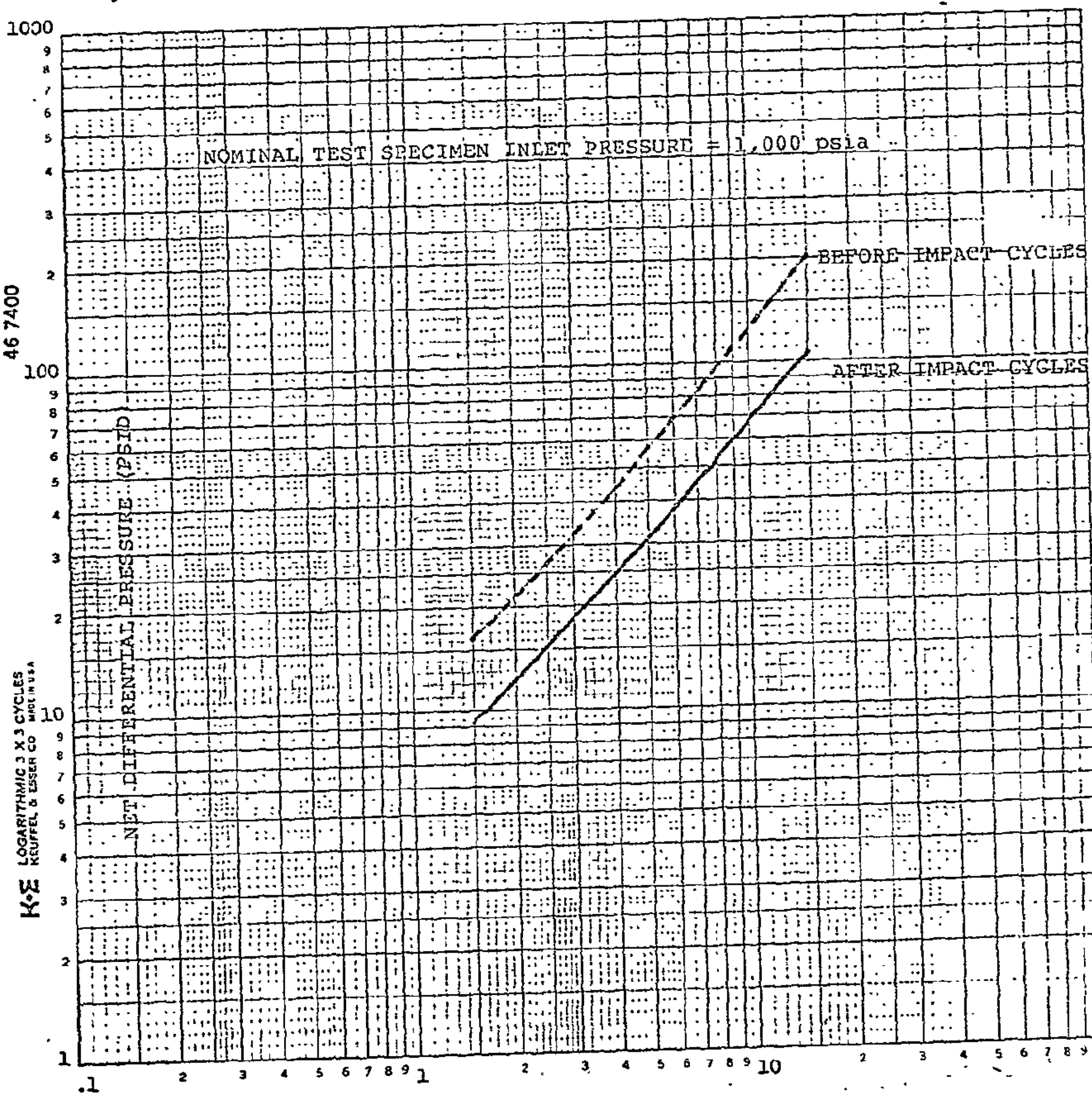
Figure 55

TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

USING SPECIMEN S/N 024 WHICH WAS NOT PROOF-PRESSURE-TESTED

INFLUENCE OF 80 HIGH PRESSURE (10,000 PSIA [703.07 Kg/cm^2] NOMINAL GN_2 IMPACT CYCLES ON THE FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF THE TEST SPECIMEN



FLOW RATE (lbs GN_2/hr)

AUG 10 1985

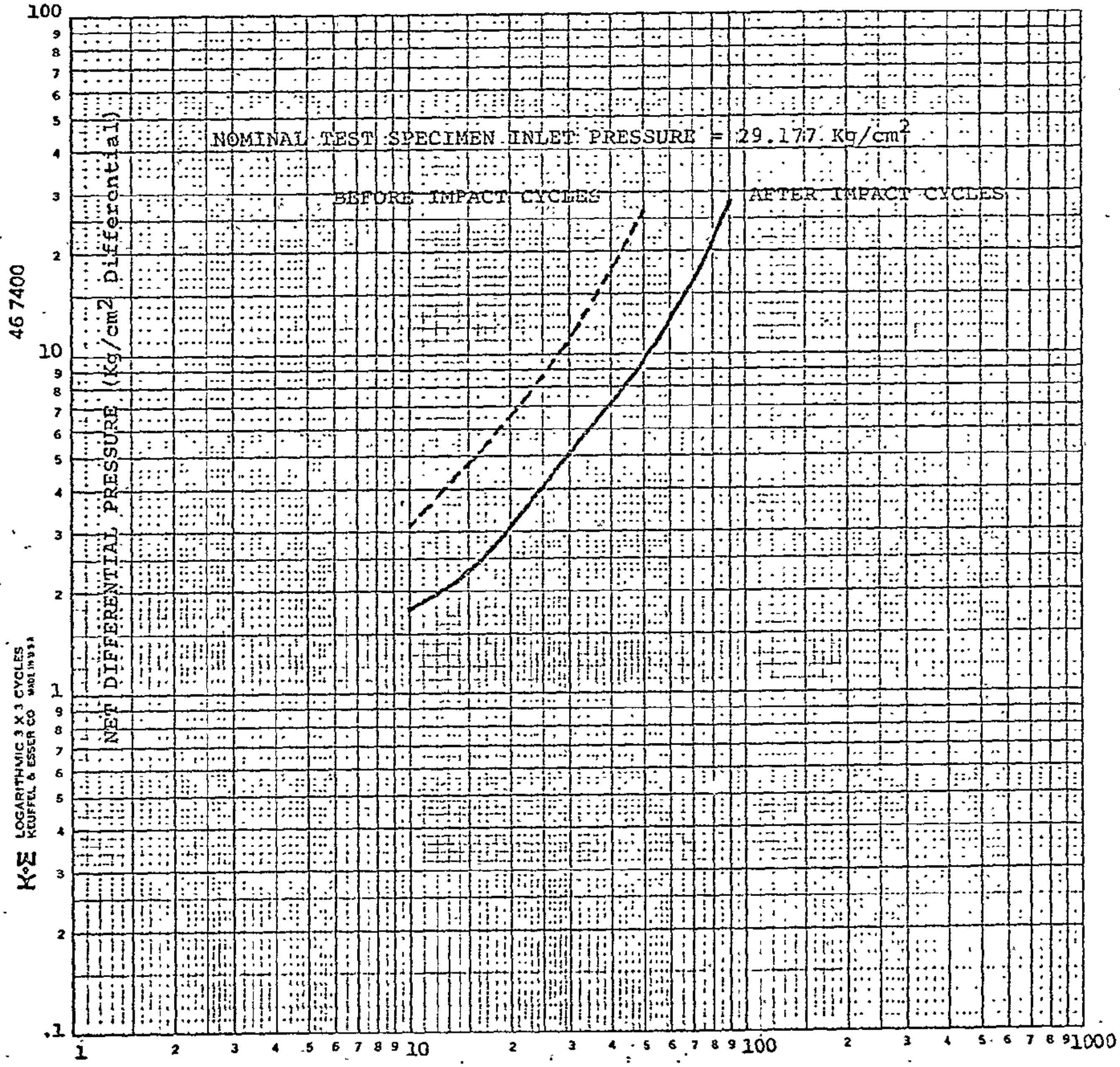
Figure 56

TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

USING SPECIMEN S/N 024 WHICH WAS NOT PROOF-PRESSURE-TESTED

INFLUENCE OF 80 HIGH PRESSURE (10,000 PSIA [703.07 Kg/cm^2] NOMINAL GN_2 IMPACT CYCLES ON THE FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF THE TEST SPECIMEN



FLOW RATE (liters* GN_2/min)

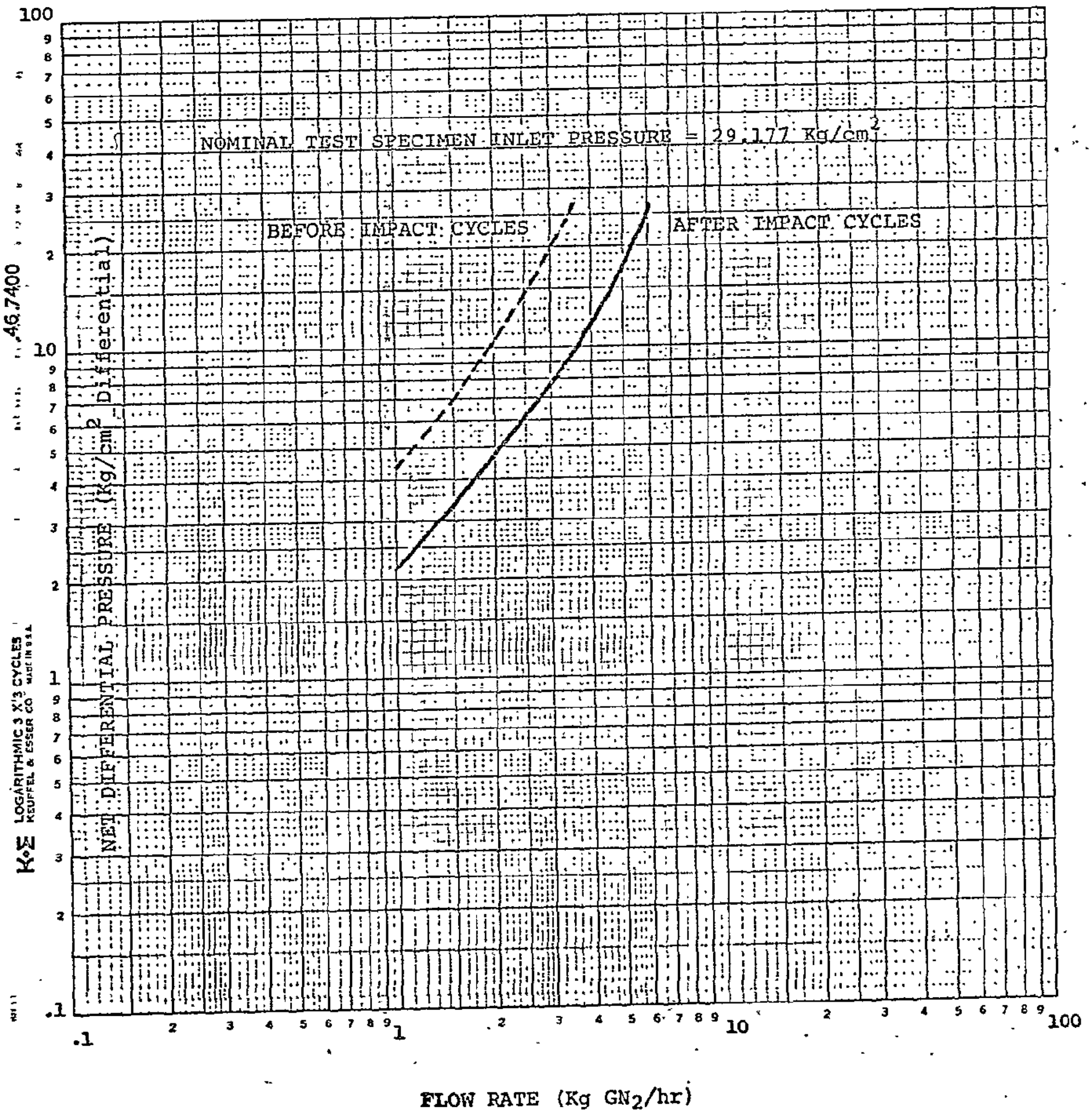
*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

Figure 57

TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE
USING SPECIMEN S/N 024 WHICH WAS NOT PROOF-PRESSURE-TESTED

INFLUENCE OF 80 HIGH PRESSURE (10,000 PSIA [703.07 Kg/cm^2]. NOMINAL GN_2 IMPACT CYCLES ON THE FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF THE TEST SPECIMEN

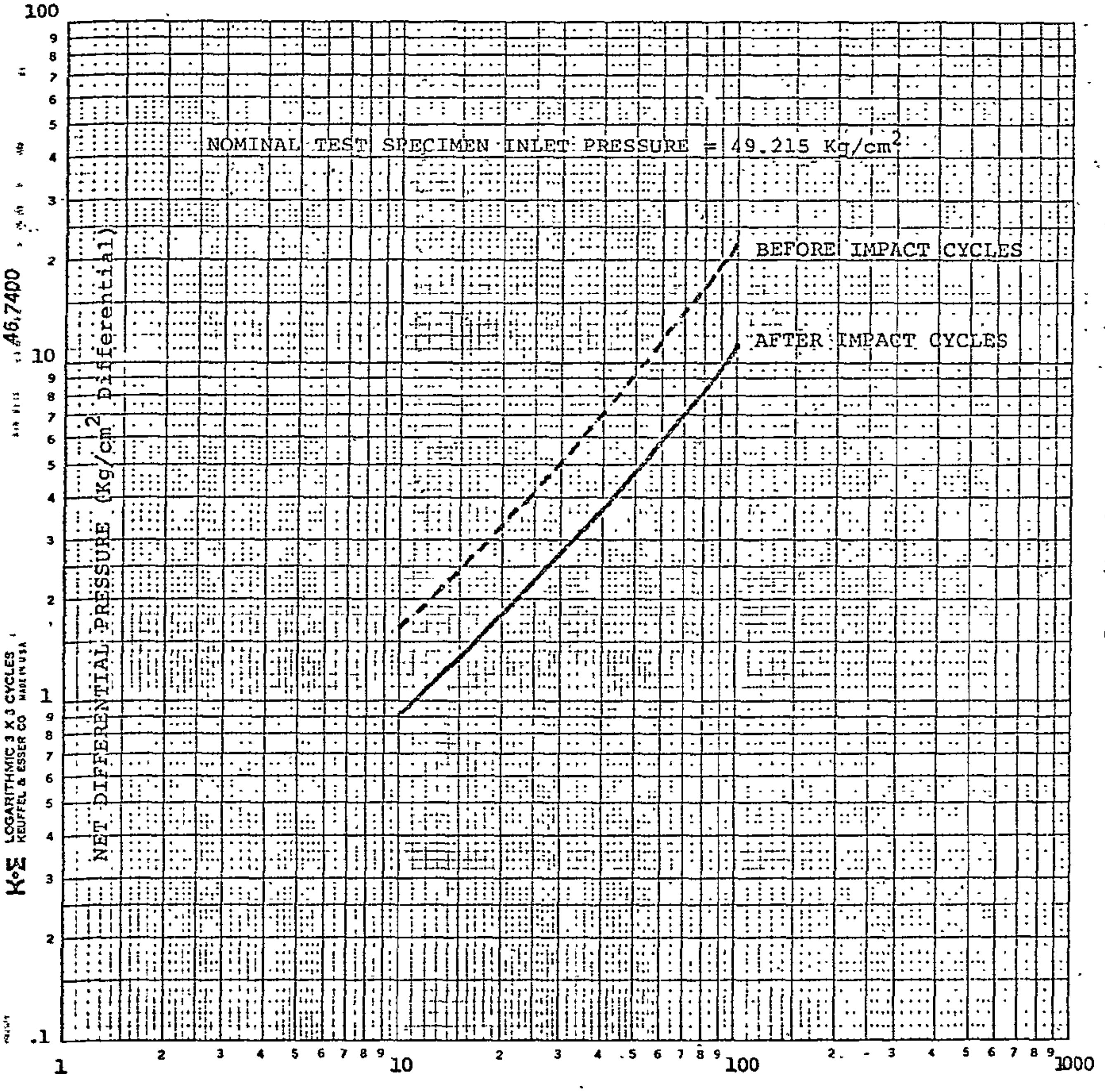


TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

USING SPECIMEN S/N 024 WHICH WAS NOT PROOF-PRESSURE-TESTED

INFLUENCE OF 80 HIGH PRESSURE (10,000 PSIA [703.07 Kg/cm^2] NOMINAL GN_2 IMPACT CYCLES ON THE FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF THE TEST SPECIMEN



*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

USING SPECIMEN S/N 024 WHICH WAS NOT PROOF-PRESSURE-TESTED

INFLUENCE OF 80 HIGH PRESSURE (10,000 PSIA [703.07 Kg/cm^2] NOMINAL GN_2 IMPACT CYCLES ON THE FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF THE TEST SPECIMEN

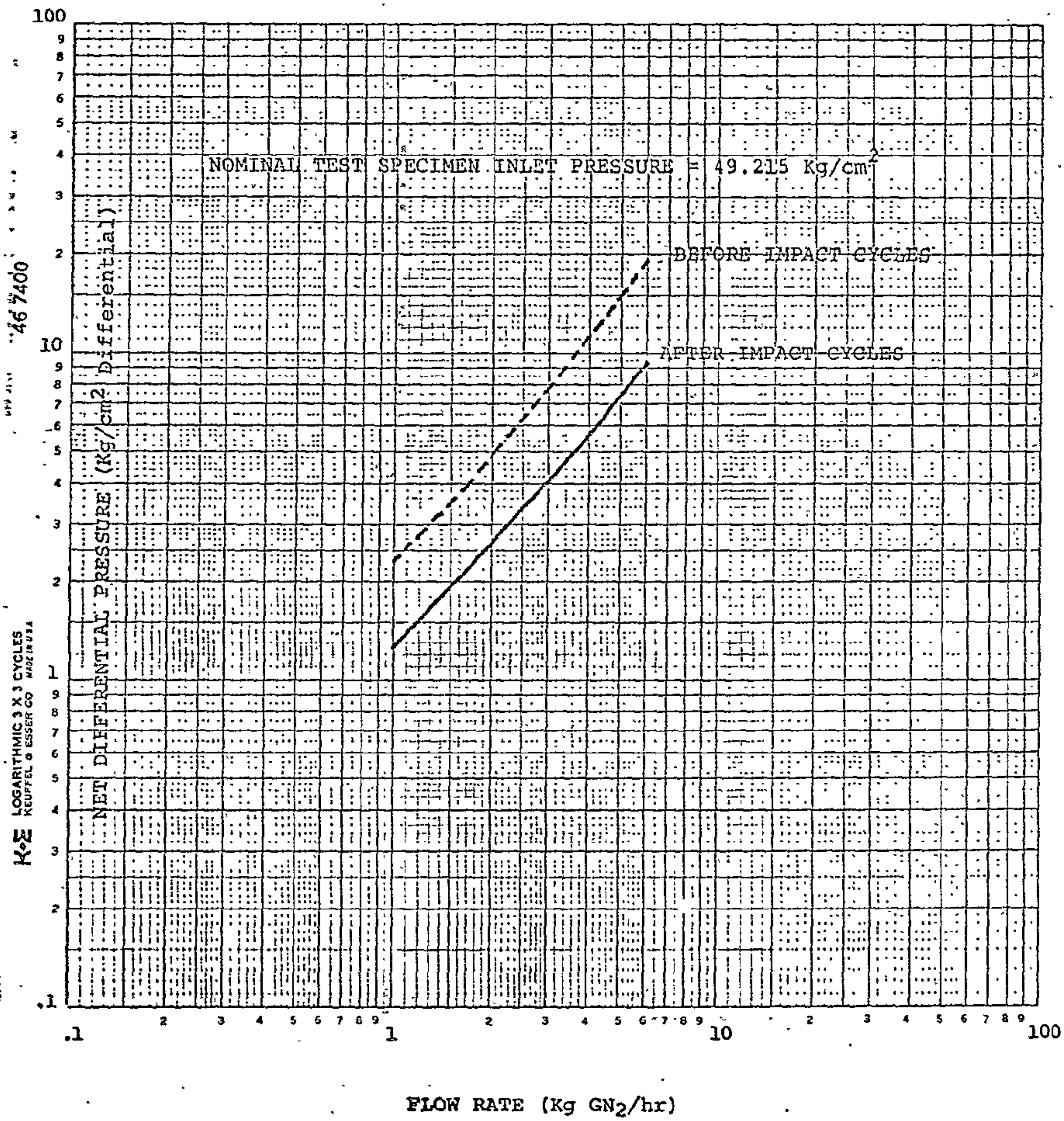


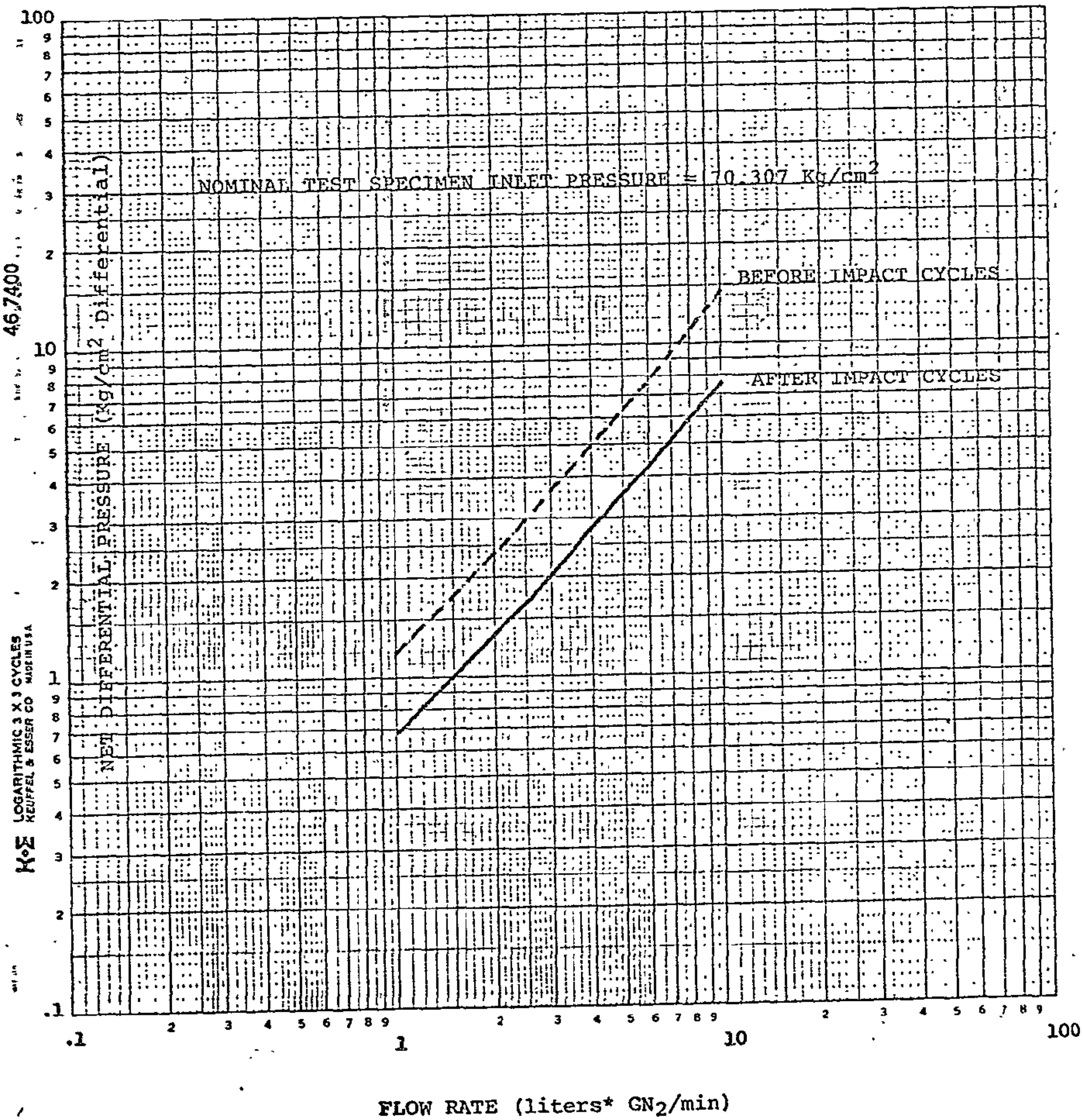
Figure 60

TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

USING SPECIMEN S/N 024 WHICH WAS NOT PROOF-PRESSURE-TESTED

INFLUENCE OF 80 HIGH PRESSURE (10,000 PSIA [703.07 Kg/cm^2] NOMINAL GN_2 IMPACT CYCLES ON THE FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF THE TEST SPECIMEN



*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

TEST NO. 6

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

USING SPECIMEN S/N 024 WHICH WAS NOT PROOF-PRESSURE-TESTED

INFLUENCE OF 80 HIGH PRESSURE (10,000 PSIA [703.07 Kg/cm^2] NOMINAL GN_2 IMPACT CYCLES ON THE FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF THE TEST SPECIMEN

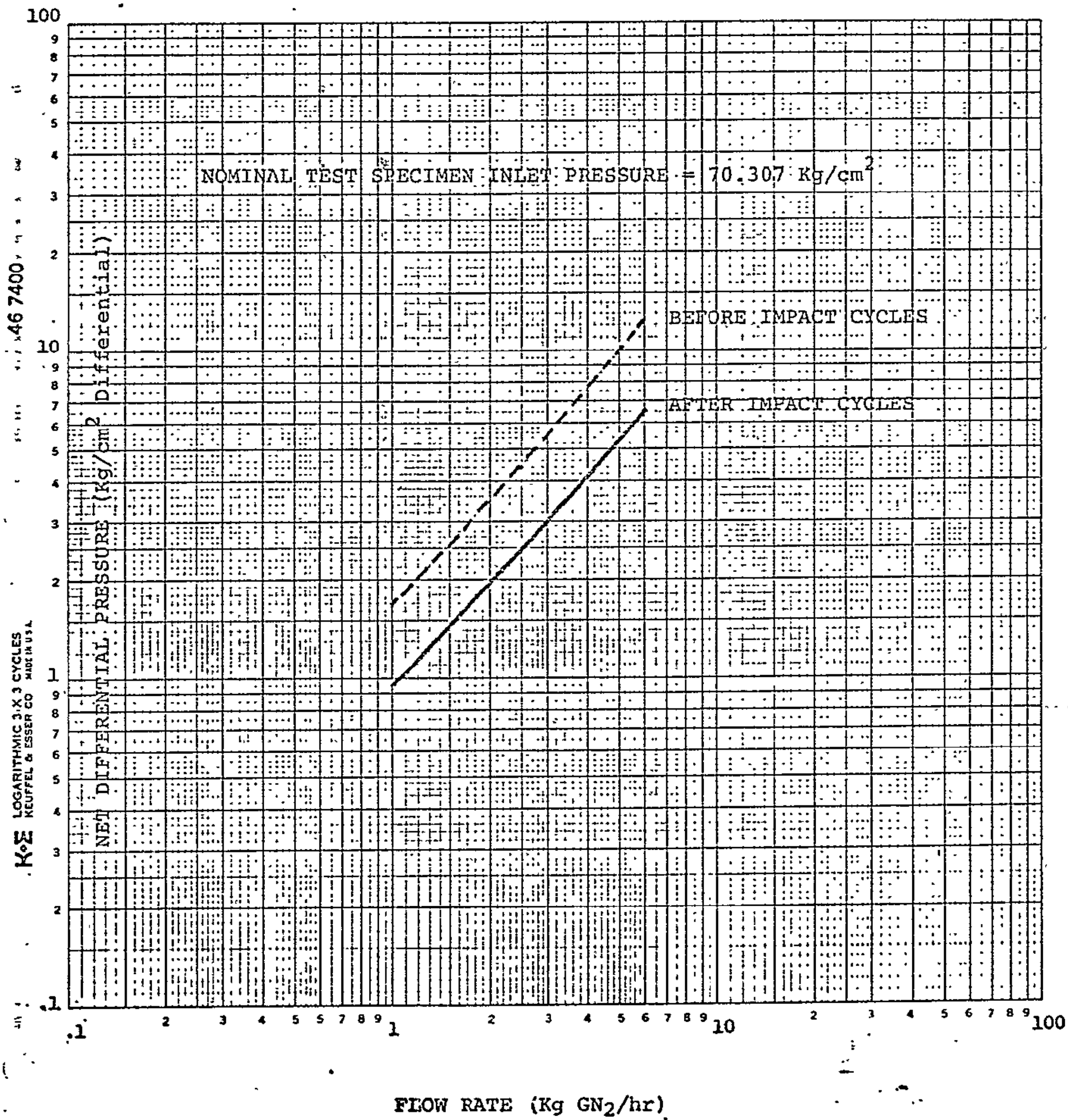


Table XXXV

TEST NO. 6

TEST SPECIMEN S/N 024

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

Prior to Impact Data

FLOW RATE (liters* GN_2/min)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential) TEST SPECIMEN INLET PRESSURE (Kg/cm^2)		
	29.254[A]	49.281[B]	70.740[C]
10	3.115	1.628	1.186
15	4.706	2.471	1.762
20	6.460	3.333	2.359
25	8.504	4.223	2.977
30	10.933	5.147	3.614
35	13.836	6.108	4.270
40	17.305	7.110	4.944
45	21.441	8.153	5.636
50	26.358	9.239	6.344
55	------	10.370	7.069
60	------	11.546	7.809
65	------	12.768	8.565
70	------	14.038	9.335
75	------	15.356	10.120
80	------	16.723	10.918
85	------	18.140	11.731
90	------	19.608	12.556
95	------	21.127	13.395
100	------	22.698	14.247

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log } (\text{Kg/cm}^2 \text{ differential}) = a + b\,(\log \text{ liters } GN_2/\text{min}) + c\,(\log \text{ liters } GN_2/\text{min})^2 + d\,(\log \text{ liters } GN_2/\text{min})^3$$

A. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = -1.412402 + 3.592114\,(\log \text{ liters } GN_2/\text{min}) - 2.478313\,(\log \text{ liters } GN_2/\text{min})^2 + 0.792008\,(\log \text{ liters } GN_2/\text{min})^3$

Sigma = 0.232

B. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = -1.007939 + 1.557547\,(\log \text{ liters } GN_2/\text{min}) - 0.488360\,(\log \text{ liters } GN_2/\text{min})^2 + 0.150283\,(\log \text{ liters } GN_2/\text{min})^3$

Sigma = 0.049

C. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = -0.755153 + 0.704066\,(\log \text{ liters } GN_2/\text{min}) + 0.125189\,(\log \text{ liters } GN_2/\text{min})^2$

Sigma = 0.034

Table XXXV

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

Table XXXVI

TEST NO. 6

TEST SPECIMEN S/N 024

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

Prior to Impact Data

FLOW RATE ($Kg\ GN_2/hr$)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential) TEST SPECIMEN INLET PRESSURE (Kg/cm^2) 29.254[A]	49.281[B]	70.740[C]
0.5	2.057	1.093	0.848
1.0	4.399	2.314	1.660
1.5	6.993	3.567	2.524
2.0	10.211	4.887	3.438
2.5	14.312	6.289	4.399
3.0	19.553	7.785	5.404
3.5	26.224	9.381	6.451
4.0	------	11.085	7.538
4.5	------	12.901	8.662
5.0	------	14.833	9.823
5.5	------	16.887	11.019
6.0	------	19.065	12.249

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log }(\text{Kg/cm}^2\text{ differential}) = a + b\,(\log \text{Kg } GN_2/\text{hr}) + c\,(\log \text{Kg } GN_2/\text{hr})^2 + d\,(\log \text{Kg } GN_2/\text{hr})^3$$

A. $\text{Log }(\text{Kg/cm}^2\text{ differential}) = 0.643403 + 1.084085\,(\log \text{Kg } GN_2/\text{hr}) + 0.195607\,(\log \text{Kg } GN_2/\text{hr})^2 + 0.792200\,(\log \text{Kg } GN_2/\text{hr})^3$

Sigma + 0.149

B. $\text{Log }(\text{Kg/cm}^2\text{ differential}) = 0.364406 + 1.062489\,(\log \text{Kg } GN_2/\text{hr}) - 0.007234\,(\log \text{Kg } GN_2/\text{hr})^2 + 0.198300\,(\log \text{Kg } GN_2/\text{hr})^3$

Sigma = 0.047

C. $\text{Log }(\text{Kg/cm}^2\text{ differential}) = 0.220091 + 1.009544\,(\log \text{Kg } GN_2/\text{hr}) + 0.136121\,(\log \text{Kg } GN_2/\text{hr})^2$

Sigma = 0.035

Table XXXVI

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

Table XXXVII

TEST NO. 6

TEST SPECIMEN S/N 024

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

Prior To Impact Data

FLOW RATE (SCFM)	NET DIFFERENTIAL PRESSURE (PSID) TEST SPECIMEN INLET PRESSURE (PSIA) 416.1[A]	700.9[B]	1006.2[C]
0.4	48.435	25.502	18.609
0.5	61.520	32.364	23.236
0.6	75.195	39.295	27.979
0.7	89.824	46.331	32.838
0.8	105.690	53.499	37.809
0.9	123.033	60.820	42.890
1.0	142.073	68.310	48.077
1.1	163.024	75.981	53.368
1.2	186.101	83.844	58.760
1.3	211.526	91.908	64.250
1.4	239.528	100.182	69.837
1.5	270.352	108.670	75.518
1.6	304.254	117.381	81.291
1.7	341.508	126.319	87.154
1.8	382.407	135.490	93.106
1.9	-------	144.899	99.144
2.0	-------	154.550	105.268
2.1	-------	164.448	111.475
2.2	-------	174.596	117.766
2.3	-------	185.000	124.137
2.4	-------	195.663	130.589
2.5	-------	206.588	137.119
2.6	-------	217.781	143.727
2.7	-------	229.244	150.412
2.8	-------	240.982	157.173
2.9	-------	252.998	164.009
3.0	-------	265.296	170.918
3.1	-------	277.880	177.901
3.2	-------	290.753	184.956
3.3	-------	303.919	192.083
3.4	-------	317.381	199.280
3.5	-------	331.144	206.548

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\ (\text{log SCFM}) + c\ (\text{log SCFM})^2 + d\ (\text{log SCFM})^3$$

A. $\text{Log (PSID)} = 2.152511 + 1.404914\ (\text{log SCFM}) + 0.893650\ (\text{log SCFM})^2 + 0.790199\ (\text{log SCFM})^3$

Sigma = 2.095

B. $\text{Log (PSID)} = 1.834482 + 1.109429\ (\text{log SCFM}) + 0.166458\ (\text{log SCFM})^2 + 0.202773\ (\text{log SCFM})^3$

Sigma = 0.676

C. $\text{Log (PSID)} = 1.681937 + 1.089817\ (\text{log SCFM}) + 0.135634\ (\text{log SCFM})^2$

Sigma = 0.503

Table XXXVII

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300 BRUNSWICK

Table XXXVIII

TEST NO. 6

TEST SPECIMEN S/N 024

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

Prior To Impact Data

FLOW RATE (lbs GN_2/hr)	NET DIFFERENTIAL PRESSURE (PSID) TEST SPECIMEN INLET PRESSURE (PSIA)		
	416.1^A	700.9^B	1006.2^C
1.0	26.083	13.938	11.017
1.5	41.407	21.817	16.135
2.0	56.336	29.685	21.402
2.5	71.815	37.626	26.824
3.0	88.463	45.700	32.399
3.5	106.725	53.950	38.123
4.0	126.968	62.407	43.993
4.5	149.525	71.094	50.003
5.0	174.720	80.029	56.150
5.5	202.885	89.226	62.428
6.0	234.364	98.697	68.836
6.5	269.521	108.453	75.368
7.0	308.744	118.504	82.023
7.5	352.452	128.856	88.797
8.0	401.091	139.519	95.687
8.5	-------	150.499	102.692
9.0	-------	161.803	109.809
9.5	-------	173.437	117.036
10.0	-------	185.407	124.370
10.5	-------	197.720	131.811
11.0	-------	210.381	139.356
11.5	-------	223.395	147.003
12.0	-------	236.769	154.752
12.5	-------	250.508	162.600
13.0	-------	264.617	170.547
13.5	-------	279.102	178.591
14.0	-------	293.969	186.730
14.5	-------	309.222	194.964
15.0	-------	324.867	203.291

NOTE: Data values obtained from lease square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{ lbs } GN_2/hr) + c\,(\log \text{ lbs } GN_2/hr)^2 + d\,(\log \text{ lbs } GN_2/hr)^3$$

A. $\text{Log (PSID)} = 1.416352 + 1.222198\,(\log \text{ lbs } GN_2/hr) - 0.605237\,(\log \text{ lbs } GN_2/hr)^2 + 0.783060\,(\log \text{ lbs } GN_2/hr)^3$

Sigma = 2.116

B. $\text{Log (PSID)} = 1.144190 + 1.136008\,(\log \text{ lbs } GN_2/hr) - 0.209811\,(\log \text{ lbs } GN_2/hr)^2 + 0.197740\,(\log \text{ lbs } GN_2/hr)^3$

Sigma = 0.684

C. $\text{Log (PSID)} = 1.042060 + 0.917266\,(\log \text{ lbs } GN_2/hr) + 0.135390\,(\log \text{ lbs } GN_2/hr)^2$

Sigma = 0.501

Table XXXVIII

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

TEST NO. 6

TEST SPECIMEN S/N 024

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

DATA AFTER 80 HIGH PRESSURE (703.07 Kg/cm^2 NOMINAL) GN_2 IMPACTS

FLOW RATE (liters* GN_2/min)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential) TEST SPECIMEN INLET PRESSURE (Kg/cm^2)		
	29.343^A	49.433^B	70.837^C
10	1.792	0.903	0.684
15	2.286	1.360	1.009
20	3.101	1.816	1.342
25	4.022	2.278	1.682
30	4.991	2.748	2.030
35	5.995	3.231	2.384
40	7.048	3.728	2.746
45	8.174	4.239	3.114
50	9.403	4.766	3.489
55	10.770	5.310	3.869
60	12.317	5.872	4.256
65	14.088	6.451	4.649
70	16.138	7.048	5.047
75	18.529	7.664	5.450
80	21.336	8.299	5.859
85	24.647	8.953	6.273
90	28.571	9.628	6.723
95	------	10.322	7.116
100	------	11.036	7.545

*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log } (\text{Kg/cm}^2 \text{ differential}) = a + b\,(\text{log liters } GN_2/\text{min}) + c\,(\text{log liters } GN_2/\text{min})^2 + d\,(\text{log liters } GN_2/\text{min})^3 + 3\,(\text{log liters } GN_2/\text{min})^4$$

A. $$\text{Log } (\text{Kg/cm}^2 \text{ differential}) = 11.632920 - 33.789530\,(\text{log liters } GN_2/\text{min}) + 36.182736\,(\text{log liters } GN_2/\text{min})^2 - 16.646127\,(\text{log liters } GN_2/\text{min})^3 + 2.873332\,(\text{log liters } GN_2/\text{min})^4$$

Sigma = 0.131

B. $$\text{Log } (\text{Kg/cm}^2 \text{ differential}) = -1.330455 + 1.711651\,(\text{log liters } GN_2/\text{min}) - 0.588602\,(\text{log liters } GN_2/\text{min})^2 + 0.163049\,(\text{log liters } GN_2/\text{min})^3$$

Sigma = 0.052

C. $$\text{Log } (\text{Kg/cm}^2 \text{ differential}) = -1.008060 + 0.742811\,(\text{log liters } GN_2/\text{min}) + 0.100021\,(\text{log liters } GN_2/\text{min})^2$$

Sigma = 0.039

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

TEST NO. 6 Table XL

TEST SPECIMEN S/N 024

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

DATA AFTER 80 HIGH PRESSURE (703.07 Kg/cm^2 NOMINAL) GN_2 IMPACTS

FLOW RATE ($Kg\ GN_2/hr$)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential) TEST SPECIMEN INLET PRESSURE (Kg/cm^2)		
	29.343[A]	49.433[B]	70.837[C]
0.5	2.023	0.601	0.483
1.0	2.158	1.273	0.946
1.5	3.346	1.935	1.429
2.0	4.716	2.611	1.932
2.5	6.173	3.313	2.454
3.0	7.758	4.049	2.992
3.5	9.557	4.823	3.547
4.0	11.686	5.650	4.117
4.5	14.285	6.501	4.702
5.0	17.529	7.410	5.300
5.5	21.643	8.368	5.912
6.0	26.922	9.378	6.537

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (Kg/cm}^2\text{ differential)} = a + b\,(\log \text{Kg } GN_2/\text{hr}) + c\,(\log \text{Kg } GN_2/\text{hr})^2 + d\,(\log \text{Kg } GN_2/\text{hr})^3 + e\,(\log \text{Kg } GN_2/\text{hr})^4$$

A. $\text{Log (Kg/cm}^2\text{ differential)} = 0.333983 + 0.914813\,(\log \text{Kg } GN_2/\text{hr}) + 1.450049\,(\log \text{Kg } GN_2/\text{hr})^2 - 3.356703\,(\log \text{Kg } GN_2/\text{hr})^3 + 2.966974\,(\log \text{Kg } GN_2/\text{hr})^4$

Sigma = 0.132

B. $\text{Log (Kg/cm}^2\text{ differential)} = 0.104923 + 1.039567\,(\log \text{Kg } GN_2/\text{hr}) - 0.079457\,(\log \text{Kg } GN_2/\text{hr})^2 + 0.225707\,(\log \text{Kg } GN_2/\text{hr})^3$

Sigma = 0.052

C. $\text{Log (Kg/cm}^2\text{ differential)} = -0.024038 + 0.999302\,(\log \text{Kg } GN_2/\text{hr}) + 0.102065\,(\log \text{Kg } GN_2/\text{hr})^2$

Sigma = 0.037

Table XL

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

TEST NO. 6

TEST SPECIMEN S/N 024

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

DATA AFTER 80 HIGH PRESSURE (10,000 PSIA NOMINAL) GN_2 IMPACTS

FLOW RATE (SCFM)	NET DIFFERENTIAL PRESSURE (PSID) / TEST SPECIMEN INLET PRESSURE (PSIA) 417.4[A]	703.1[B]	1007.5[C]
0.4	25.829	14.098	10.613
0.5	30.263	17.823	13.237
0.6	36.276	21.525	15.906
0.7	43.116	25.230	18.621
0.8	50.429	28.958	21.380
0.9	58.032	32.722	24.183
1.0	65.836	36.535	27.027
1.1	73.816	40.406	29.912
1.2	81.986	44.342	32.837
1.3	90.388	48.349	35.801
1.4	99.081	52.432	38.802
1.5	108.140	56.595	41.839
1.6	117.647	60.843	44.912
1.7	127.694	65.179	48.020
1.8	138.382	69.606	51.162
1.9	149.817	74.126	54.338
2.0	162.115	78.742	57.546
2.1	175.404	83.457	60.785
2.2	189.818	88.273	64.057
2.3	205.510	93.191	67.359
2.4	222.642	98.215	70.691
2.5	241.397	103.345	74.053
2.6	261.975	108.585	77.444
2.7	284.601	113.934	80.864
2.8	309.523	119.396	84.313
2.9	337.018	124.972	87.789
3.0	367.398	130.663	91.293
3.1	401.012	136.472	94.823
3.2	--------	142.400	98.381
3.3	--------	148.448	101.965
3.4	--------	154.619	105.575
3.5	--------	160.913	109.211

Table XLI

NOTE: Data Values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{SCFM}) + c\,(\log \text{SCFM})^2 + d\,(\log \text{SCFM})^3 + e\,(\log \text{SCFM})^4$$

A. $$\text{Log (PSID)} = 1.818463 + 1.198842\,(\log \text{SCFM}) + 0.027053\,(\log \text{SCFM})^2 + 0.130891\,(\log \text{SCFM})^3 + 2.977611\,(\log \text{SCFM})^4$$

Sigma = 1.885

B. $$\text{Log (PSID)} = 1.562714 + 1.051215\,(\log \text{SCFM}) + 0.120053\,(\log \text{SCFM})^2 + 0.226061\,(\log \text{SCFM})^3$$

Sigma = 0.742

C. $$\text{Log (PSID)} = 1.431800 + 1.060084\,(\log \text{SCFM}) + 0.100362\,(\log \text{SCFM})^2$$

Sigma = 0.526

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300 BRUNSWICK

Table XLII

TEST NO. 6

TEST SPECIMEN S/N 024

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

DATA AFTER 80 HIGH PRESSURE (10,000 PSIA NOMINAL) GN_2 IMPACTS

FLOW RATE ($lbs\ GN_2/hr$)	NET DIFFERENTIAL PRESSURE (PSID) TEST SPECIMEN INLET PRESSURE (PSIA) 417.4[A]	703.1[B]	1007.5[C]
1.0	33.235	7.627	6.269
1.5	24.708	12.043	9.211
2.0	28.265	16.360	12.207
2.5	34.737	20.630	15.264
3.0	42.487	24.896	18.382
3.5	50.900	29.190	21.559
4.0	59.689	33.534	24.793
4.5	68.736	37.945	28.082
5.0	78.019	42.436	31.425
5.5	87.581	47.018	34.820
6.0	97.504	51.698	38.265
6.5	107.894	56.484	41.760
7.0	118.877	61.382	45.301
7.5	130.595	66.397	48.889
8.0	143.200	71.534	52.522
8.5	156.863	76.796	56.198
9.0	171.768	82.187	59.918
9.5	188.118	87.711	63.679
10.0	206.137	93.372	67.482
10.5	226.075	99.172	71.325
11.0	248.215	105.113	75.207
11.5	272.869	111.200	79.128
12.0	300.396	117.435	83.087
12.5	331.200	123.820	87.083
13.0	365.739	130.357	91.117
13.5	404.537	137.051	95.186
14.0	-------	143.902	99.291
14.5	-------	150.913	103.430
15.0	-------	158.088	107.605

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{lbs } GN_2/\text{hr}) + c\,(\log \text{lbs } GN_2/\text{hr})^2 + d\,(\log \text{lbs } GN_2/\text{hr})^3 + e\,(\log \text{lbs } GN_2/\text{hr})^4$$

A. $\text{Log (PSID)} = 1.521591 - 1.751523\,(\log \text{lbs } GN_2/\text{hr}) + 7.011529\,(\log \text{lbs } GN_2/\text{hr})^2 - 7.435352\,(\log \text{lbs } GN_2/\text{hr})^3 + 2.967910\,(\log \text{lbs } GN_2/\text{hr})^4$

Sigma = 1.874

B. $\text{Log (PSID)} = 0.882374 + 1.174645\,(\log \text{lbs } GN_2/\text{hr}) - 0.313020\,(\log \text{lbs } GN_2/\text{hr})^2 + 0.226217\,(\log \text{lbs } GN_2/\text{hr})^3$

Sigma = 0.739

C. $\text{Log (PSID)} = 0.797231\,(\log \text{lbs } GN_2/\text{hr}) + 0.930919\,(\log \text{lbs } GN_2/\text{hr})^2 + 0.101038\,(\log \text{lbs } GN_2/\text{hr})^3$

Sigma = 0.526

Table XLIII

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

TEST NO. 6

HPOF SPECIMEN S/N 024

TYPICAL GN_2 PRESSURE IMPACT DATA

		PEAK PRESSURE VALUES (PSIA)			
IMPACT NO.	PRESSURE UPSTREAM OF ECV-1 PT-2 (PSIA)	PT-12 KISTLER UPSTREAM OF TEST SPECIMEN	RATIO OF PEAK IMPACT PRESSURE TO ECV-1 INLET PRESSURE	PT-13 KISTLER DOWNSTREAM OF TEST SPECIMEN	APPROXIMATE TIME OF PT-13 PEAK PRESSURE AFTER PT-12 PEAK VALUE (SEC)
1	10,530	9,859	0.936	3,835	0.2
2	10,490	9,837	0.938	3,851	0.2
3	10,510	9.794	0.932	3,926	0.2

Table XLIII

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

BRUNSWICK

Table XLIV

P/N 9-812 S/N 030

Flow - ΔP, Proof and Bubble Point Tests

Sequence	Description
1	Initial Bubble Point
2N	Flow- ΔP in Normal Flow Direction
2R	Flow- ΔP in Reverse Flow Direction
3	Proof Pressure Normal Direction
4	Initial Bubble Point
5N	Flow- ΔP in Normal Direction
5R	Flow- ΔP in Reverse Direction
6	Proof Pressure Normal Direction
7	Initial Bubble Point
8N	Flow- ΔP in Normal Direction
8R	Flow- ΔP in Reverse Direction
9	Relax Overnight-Static Condition
10N	Flow- ΔP in Normal Direction
10R	Flow- ΔP in Reverse Direction
11	Proof in Normal Direction
12	Initial Bubble Point
13N	Flow- ΔP in Normal Direction
13R	Flow- ΔP in Reverse Direction
14	Relax Overnight-Static Condition
15N	Flow- ΔP in Normal Direction
15R	Flow- ΔP in Reverse Direction
16	Proof Pressure Reverse Direction
17	Initial Bubble Point
18N	Flow- ΔP in Normal Direction
18R	Flow- ΔP in Reverse Direction

Table XLIV

P/N 9-812 S/N 030

Flow- ΔP, Proof and Bubble Point Tests

Sequence	Description
19	Relax Overnight-Static Condition
20N	Flow- ΔP in Normal Direction
20R	Flow- ΔP in Reverse Direction

When the part is in its normal direction, the S/N is on the upstream side of the part.

All flow tests conducted at 400 PSIG inlet pressure.

N = Normal Flow Direction

R = Reverse Flow Direction

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TABLE XLV

WINTEC CORPORATION

Los Angeles, California 90045

ACCEPTANCE TEST DATA SHEET
TP
REVISION

S/O NO. S/N 030

SHT. OF

CUSTOMER	CUST. SPEC.	REV.	CUST. P/N	REV.	WINTEC P/N	REV.
NASA					9-812	

Gross & Net △P are the same because of no measurable difference in the tare

SEQUENCE	GROSS △P 1.28 SCFM	GROSS △P 1.38 SCFM	GROSS △P 1.71 SCFM	GROSS △P 1.84 SCFM	GROSS △P 2.14 SCFM	GROSS △P 2.35 SCFM	INLET PRESS. 400 PSIG	PROOF PRESSURE		BUBBLE POINT OBSERVED in. Hg	Bubble Point Observed in. H_2O	Fluid Temp °F	Density of Fluid	Surface Tension	Standard Bubble Point In. H_2O
1	--	--	--	--	--	--	--	--		4.25	57.783	75°	.7812	21.24	57.149
2N	159	162	199	284	400		400	--		--	--	--	--	--	--
2R	162	178	255	295	399		400	--		--	--	--	--	--	--
3	--	--	--	--	--	--	--	Normal		--	--	--	--	--	--
4	--	--	--	--	--	--	--	--		3.937	53.527	75	.7812	21.24	52.911
5N	87	93	.128	142	180	205	400	--		--	--	--	--	--	--
5R	143	155	209	250	345	399	400	--		--	--	--	--	--	--
6	--	--	--	--	--	--	--	Normal		--	--	--	--	--	--
7	--	--	--	--	--	--	--	--		4.375	59.482	75	.7812	21.24	58.841
8N	120	130	178	190	240	285	400	--		--	--	--	--	--	--
8R	78	84	115	128	160	183	400	--		--	--	--	--	--	--
9	Relax overnight - 24 hours--					--	--	--		--	--	--	--	--	--
10N	120	130	170	190	24	285	400	--		--	--	--	--	--	--
10R	76	84	115	125	160	185	400	--		--	--	--	--	--	--
11	--	--	--	--	--	--	--	Normal		--	--	--	--	--	--

N = Normal Direction
R = Reverse Direction

INSPECTION ACCEPTANCE

TEST	INSP. P.	IBP	WT.	PROOF	LEAK	FLOW	CLEAN			GOV'T.
WINTEC										
CUSTOMER										
DATE										

INSTRUMENTATION LIST

PARA.	CODE	RANGE	STK. #	CALIB.	PARA.	CODE	RANGE	STK. #	CALIB.

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TABLE XLV

WINTEC CORPORATION

Los Angeles, California 90045

ACCEPTANCE TEST DATA SHEET
TP
REVISION

S/O NO. S/N 030

SHT. OF

CUSTOMER	CUST. SPEC.	REV.	CUST. P/N	REV.	WINTEC P/N	REV.
NASA					9-812	

Gross & Net ΔP are the same because of no measurable difference in the tare

SEQUENCE	GROSS ΔP 1.28 SCFM	GROSS ΔP 1.38 SCFM	GROSS ΔP 1.71 SCFM	GROSS ΔP 1.84 SCFM	GROSS ΔP 2.14 SCFM	GROSS ΔP 2.35 SCFM	INLET PRESS. 400 PSIG	PROOF PRESSURE		BUBBLE POINT OBSERVED in. Hg	Bubble Point Observed in. H_2O	Fluid Temp °F	Density of Fluid	Surface Tension	Standard Bubble Point In H_2O
12	--	--	--	--	--	--	--	--		4.00	54.384	72	.7827	21.49	53.138
13N	78	84	115	128	162	188	400	--		--	--	--	--	--	--
13R	115	122	170	188	240	290	400	--		--	--	--	--	--	--
14	Relax	Overnight		--	--	--	--	--		--	--	--	--	--	--
15N	80	86	115	130	160	185	400	--		--	--	--	--	--	--
15R	115	125	170	190	242	285	400	--		--	--	--	--	--	--
16	--	--	--	--	--	--	--	Reverse		--	--	--	--	--	--
17	--	--	--	--	--	--	--	--		3.875	52.684	74	.7817	21.33	51.857
18N	122	135	148	198	250	299	400	--		--	--	--	--	--	--
18R	86	93	125	135	165	185	400	--		--	--	--	--	--	--
19		Relax	Overnight		--	--	--	--		--	--	--	--	--	--
20N	108	122	162	181	235	273	400	--		--	--	--	--	--	--
20R	85	91	120	130	165	185	400	--		--	--	--	--	--	--

N = Normal Direction
R = Reverse Direction

INSPECTION ACCEPTANCE

TEST	INSP. P.	IBP	WT.	PROOF	LEAK	FLOW	CLEAN			GOV'T.
WINTEC										
CUSTOMER										
DATE										

INSTRUMENTATION LIST

PARA.	CODE	RANGE	STK. #	CALIB.	PARA.	CODE	RANGE	STK. #	CALIB.

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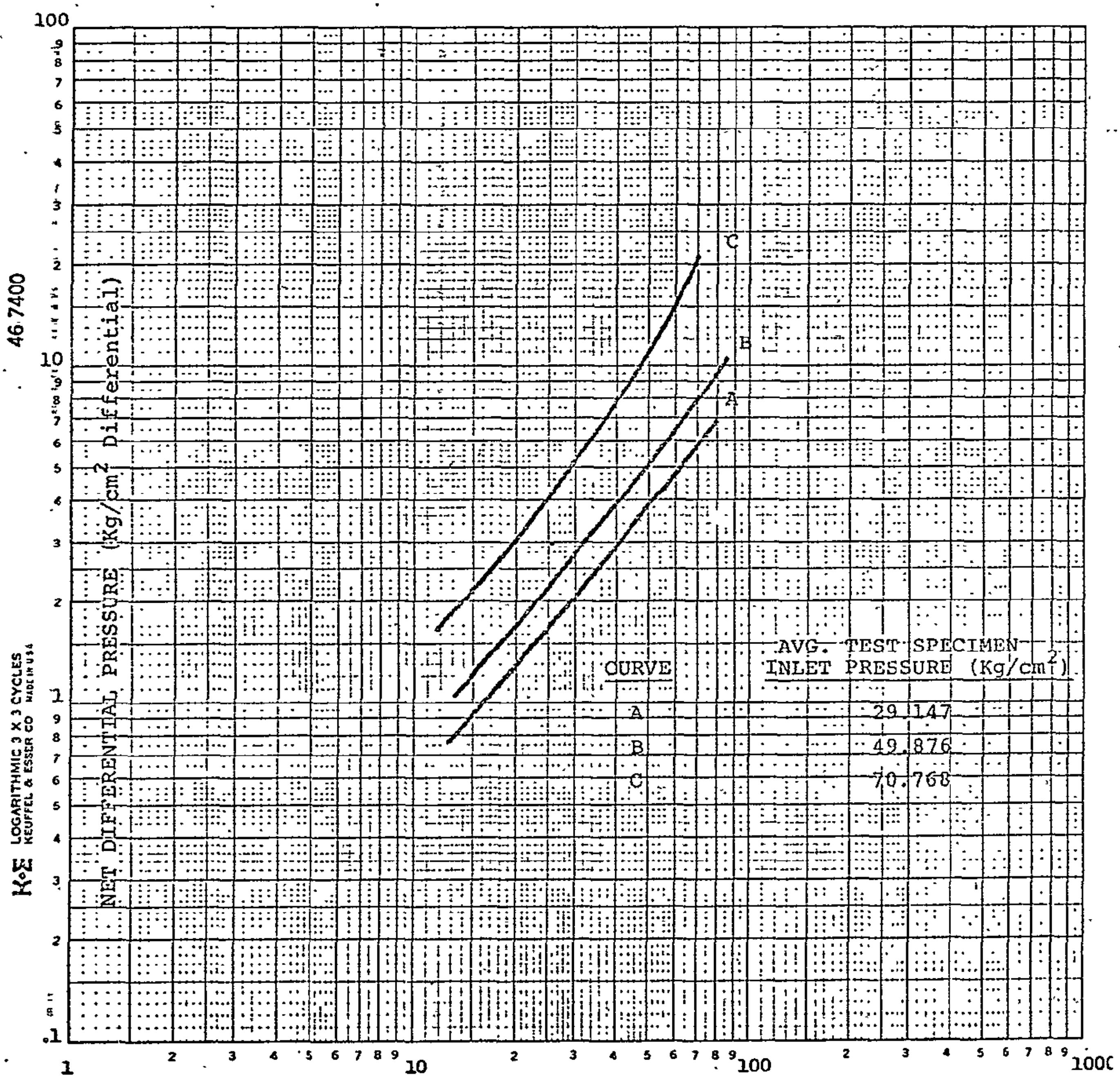
Figure 62

TEST NO. 6

TEST SPECIMEN S/N 021

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE VERSUS DIFFERENTIAL PRESSURE DATA PRIOR TO GN_2 IMPACT CYCLES



*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

Figure 63

TEST NO. 6

TEST SPECIMEN S/N 021

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE VERSUS DIFFERENTIAL PRESSURE DATA PRIOR TO GN_2 IMPACT CYCLES

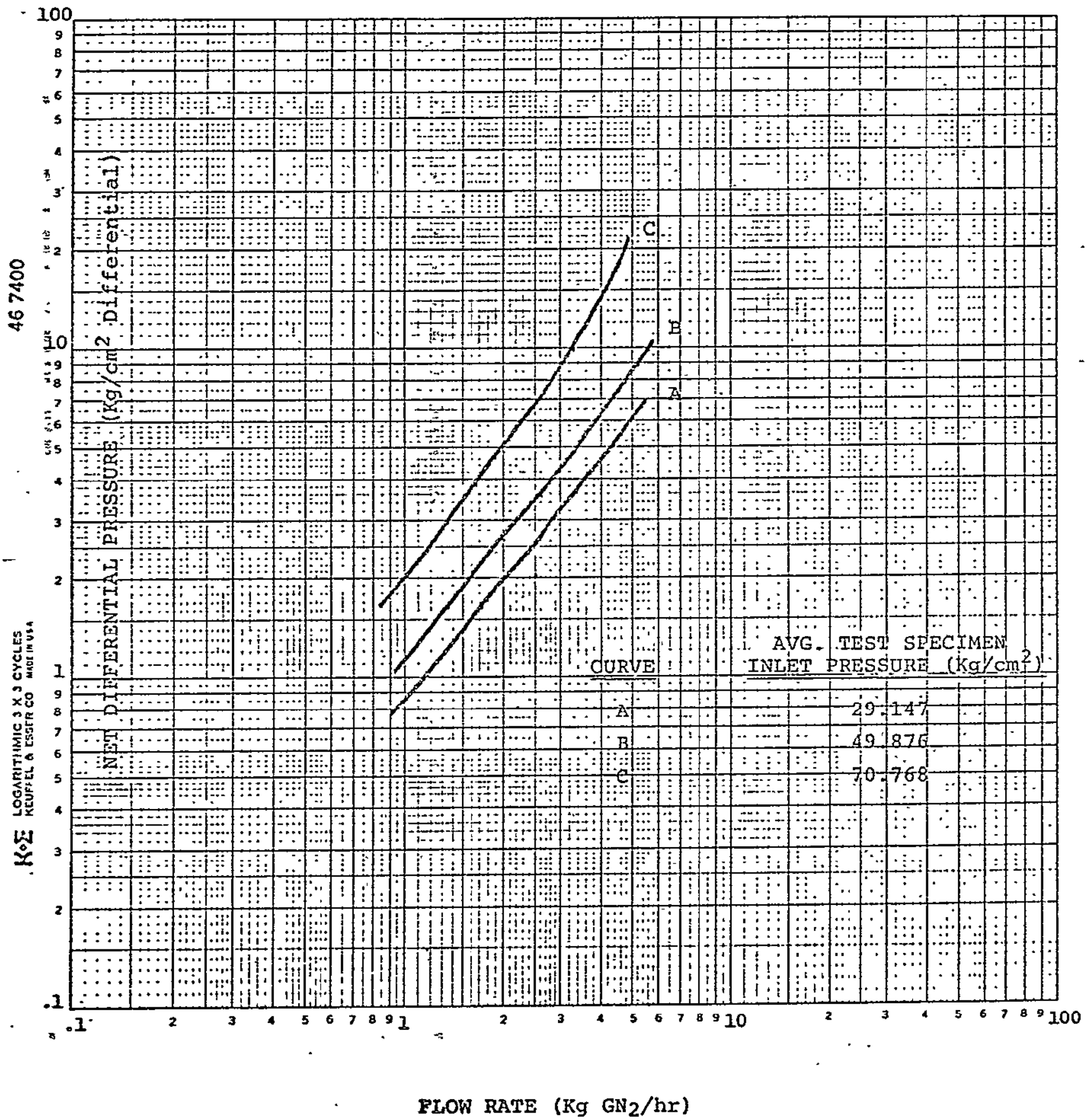


Figure 64

TEST NO. 6

TEST SPECIMEN S/N 021

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE VERSUS DIFFERENTIAL PRESSURE DATA PRIOR TO GN_2 IMPACT CYLES

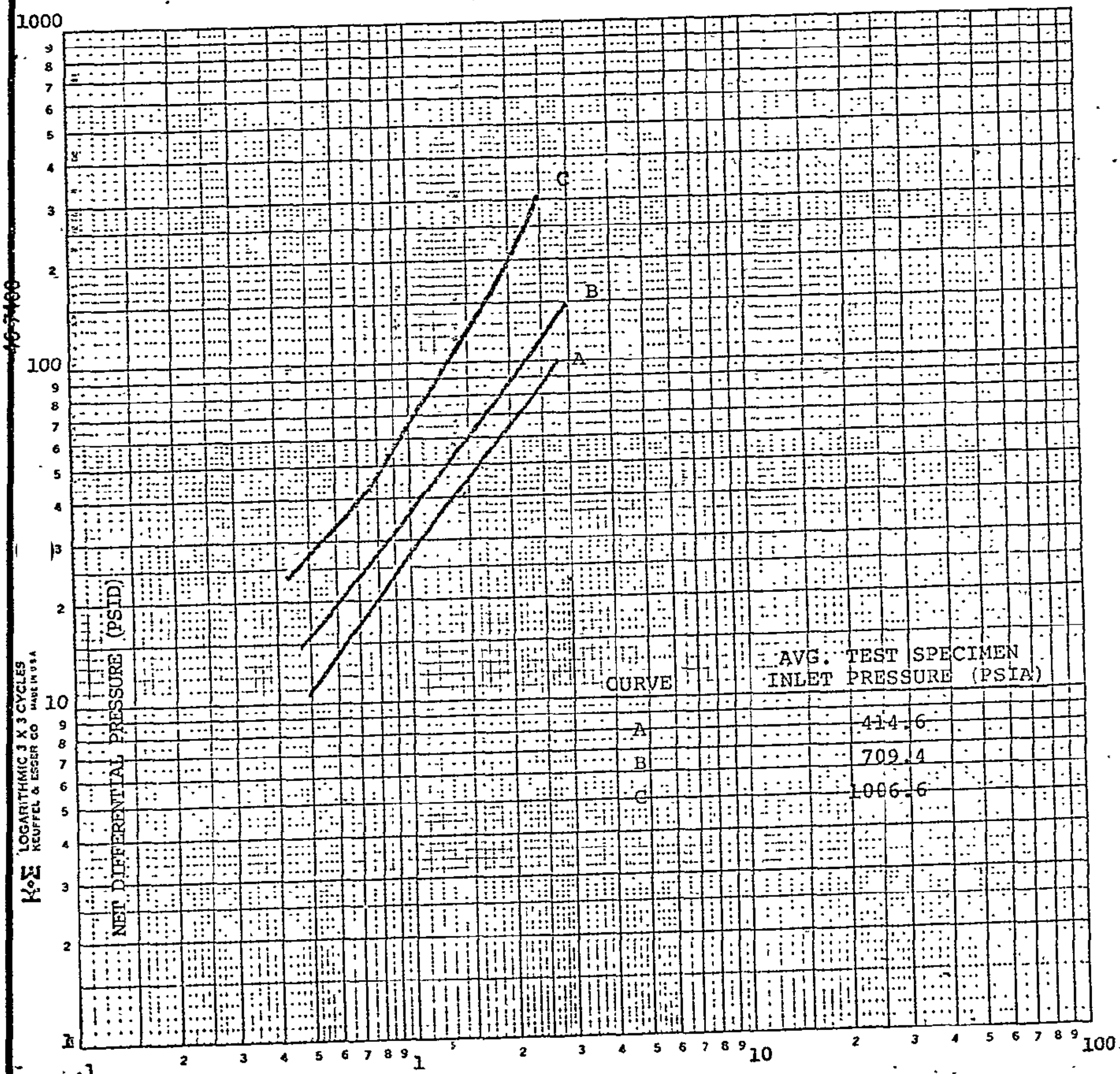


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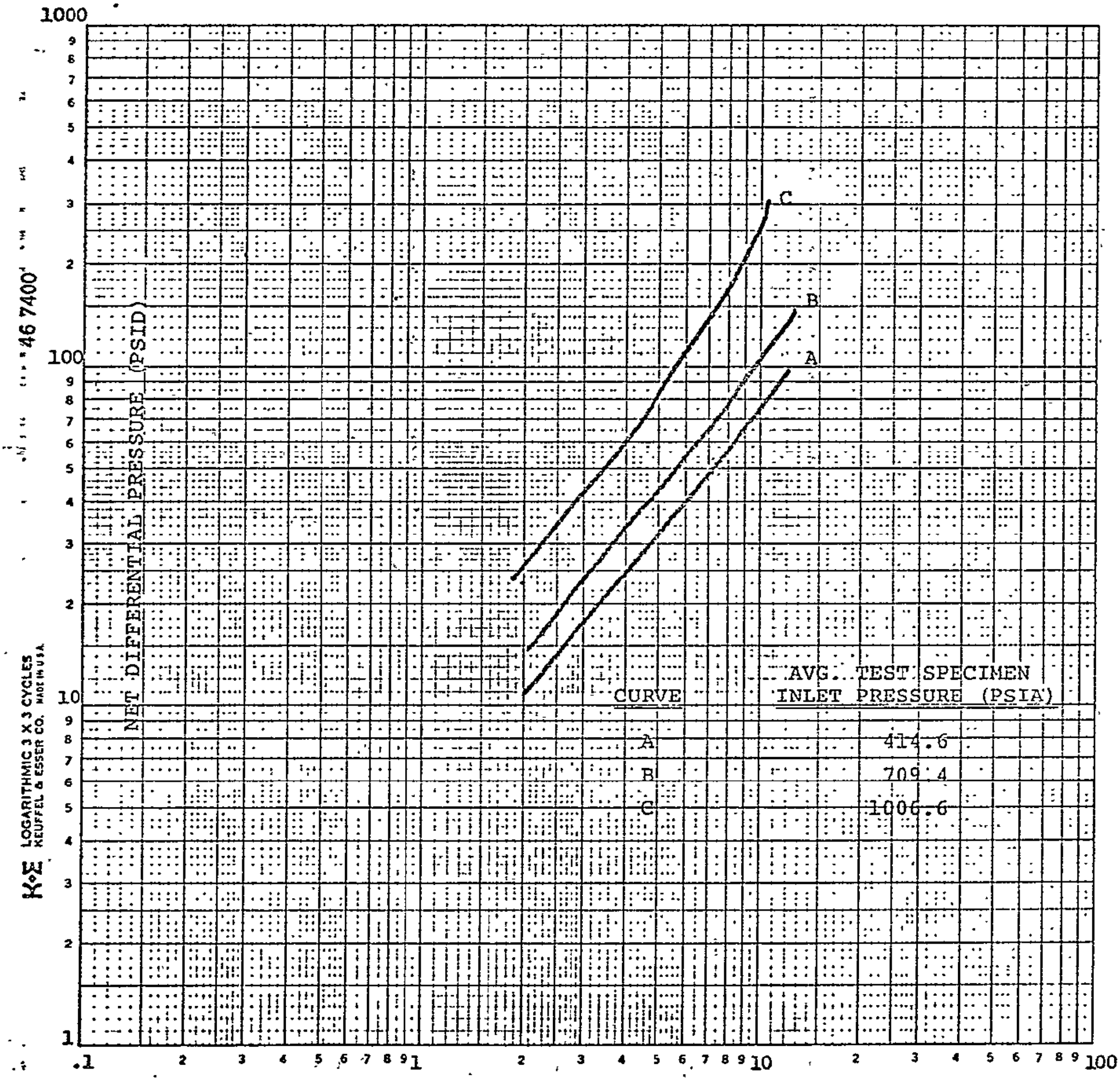
Figure 65

TEST NO. 6

TEST SPECIMEN S/N 021

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE VERSUS DIFFERENTIAL PRESSURE DATA PRIOR TO GN_2 IMPACT CYCLES



FLOW RATE (lbs GN_2/hr)

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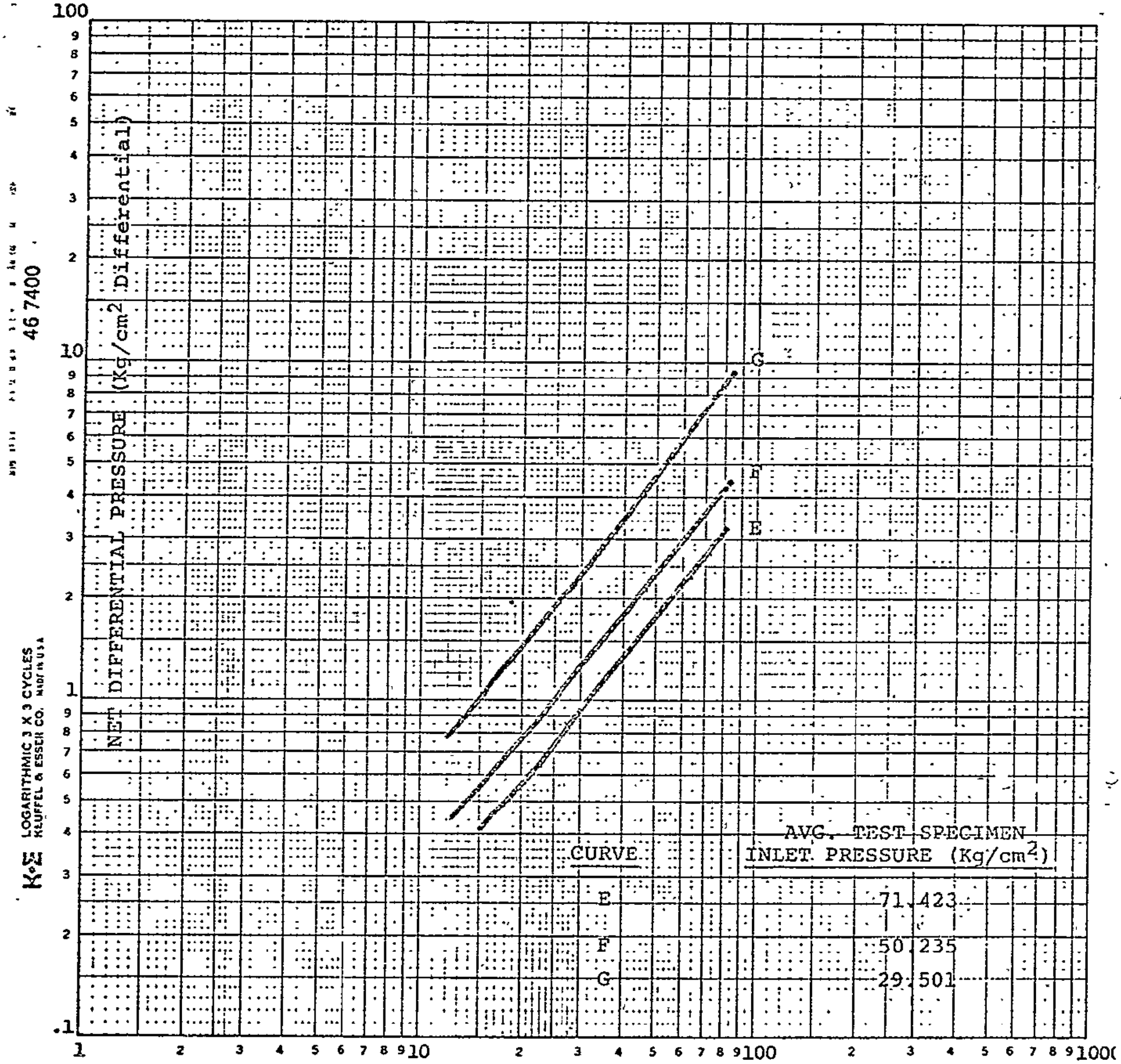
Figure 66

TEST NO. 6

TEST SPECIMEN S/N 021

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE VERSUS DIFFERENTIAL PRESSURE DATA AFTER 100 (703.07 Kg/cm^2 NOMINAL) GN_2 IMPACT CYCLES



FLOW RATE (liters*GN_2/min)

*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

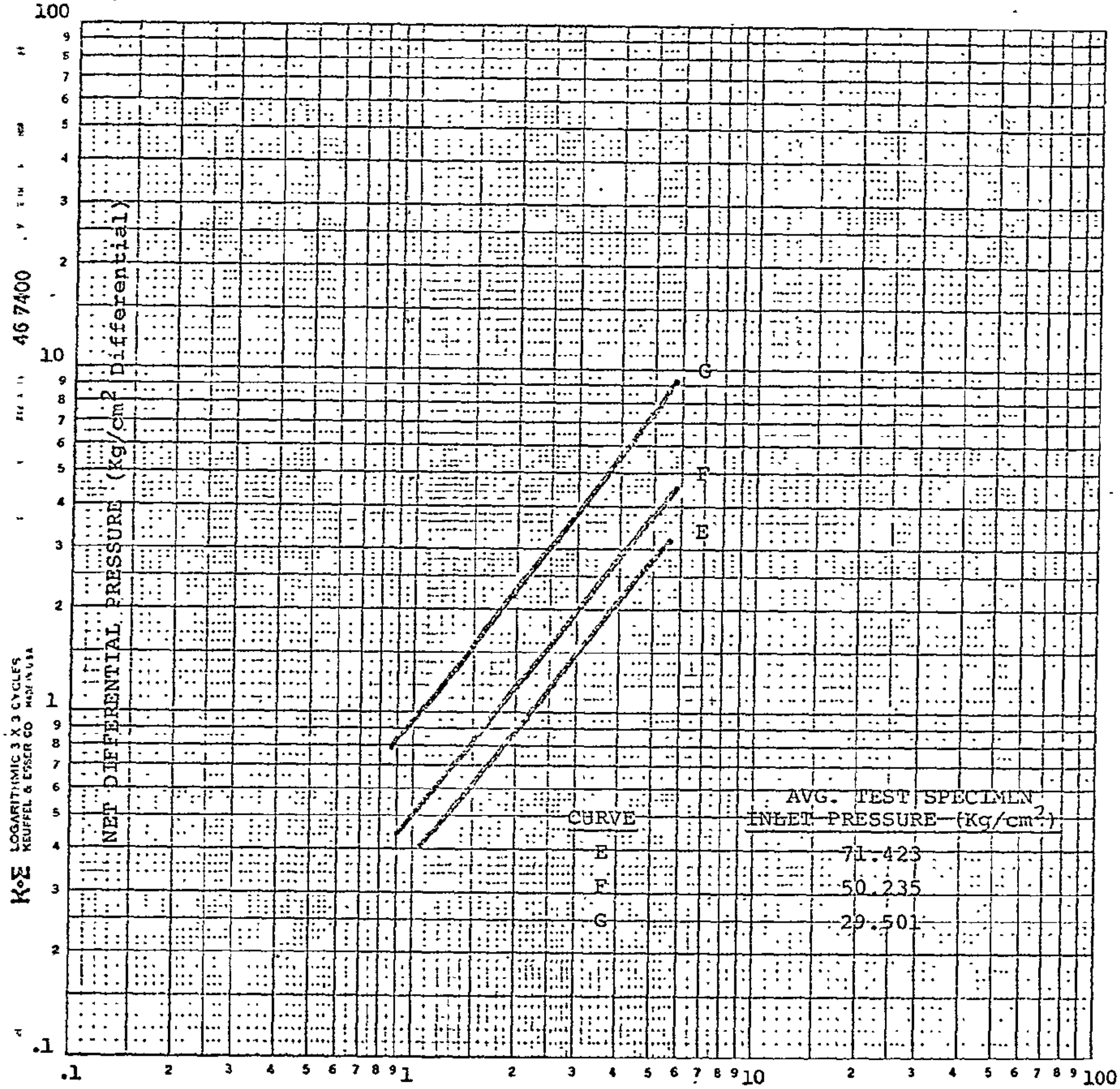
Figure 67

TEST NO. 6

TEST SPECIMEN S/N 021

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE VERSUS DIFFERENTIAL PRESSURE DATA AFTER 100 (703.07 Kg/cm^2 NOMINAL) GN_2 IMPACT CYCLES



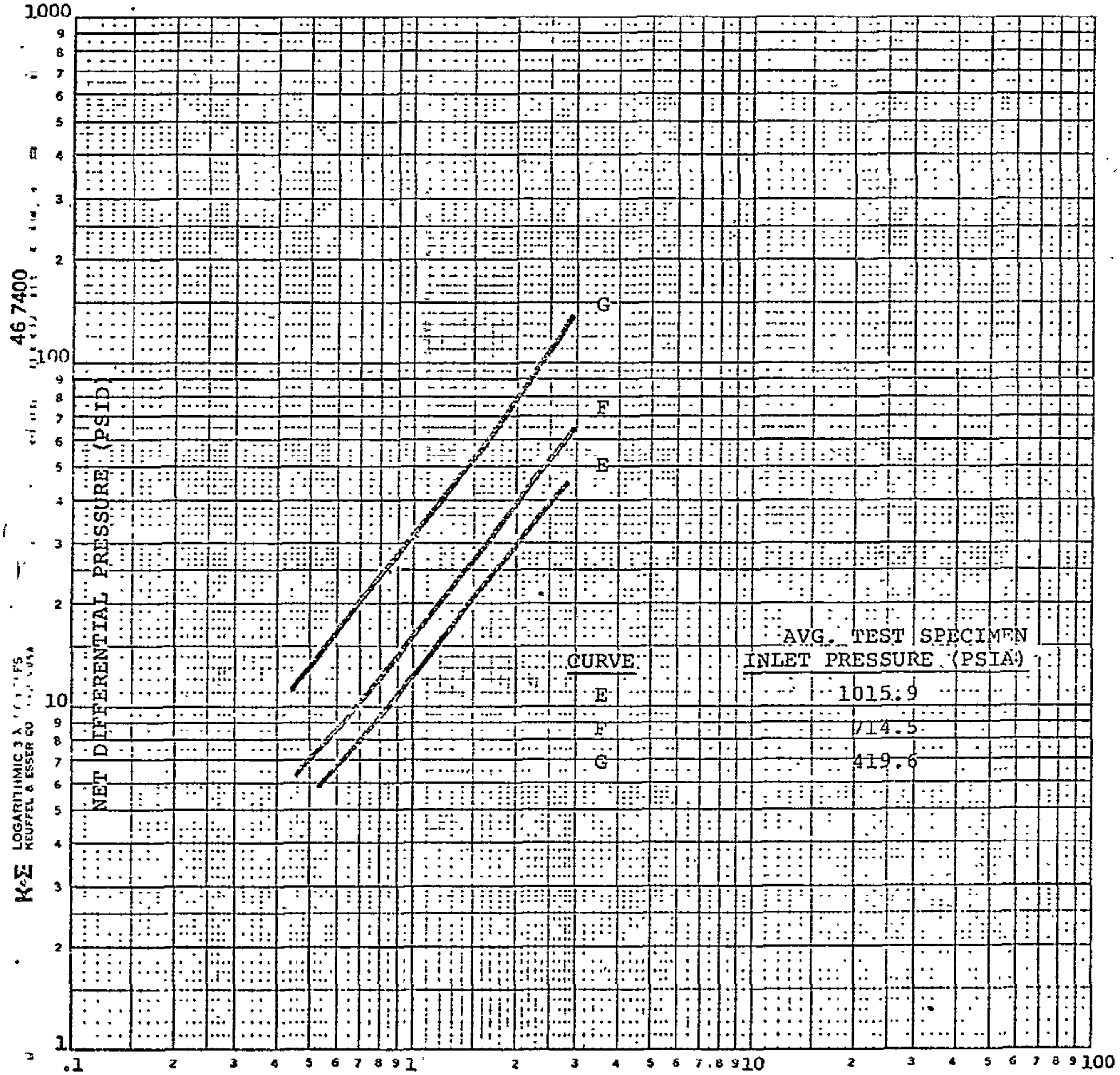
TEST NO. 6

Figure 68

TEST SPECIMEN S/N 021

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE VERSUS DIFFERENTIAL PRESSURE DATA AFTER 100 (10,000 PSIA NOMINAL) GN_2 IMPACT CYCLES



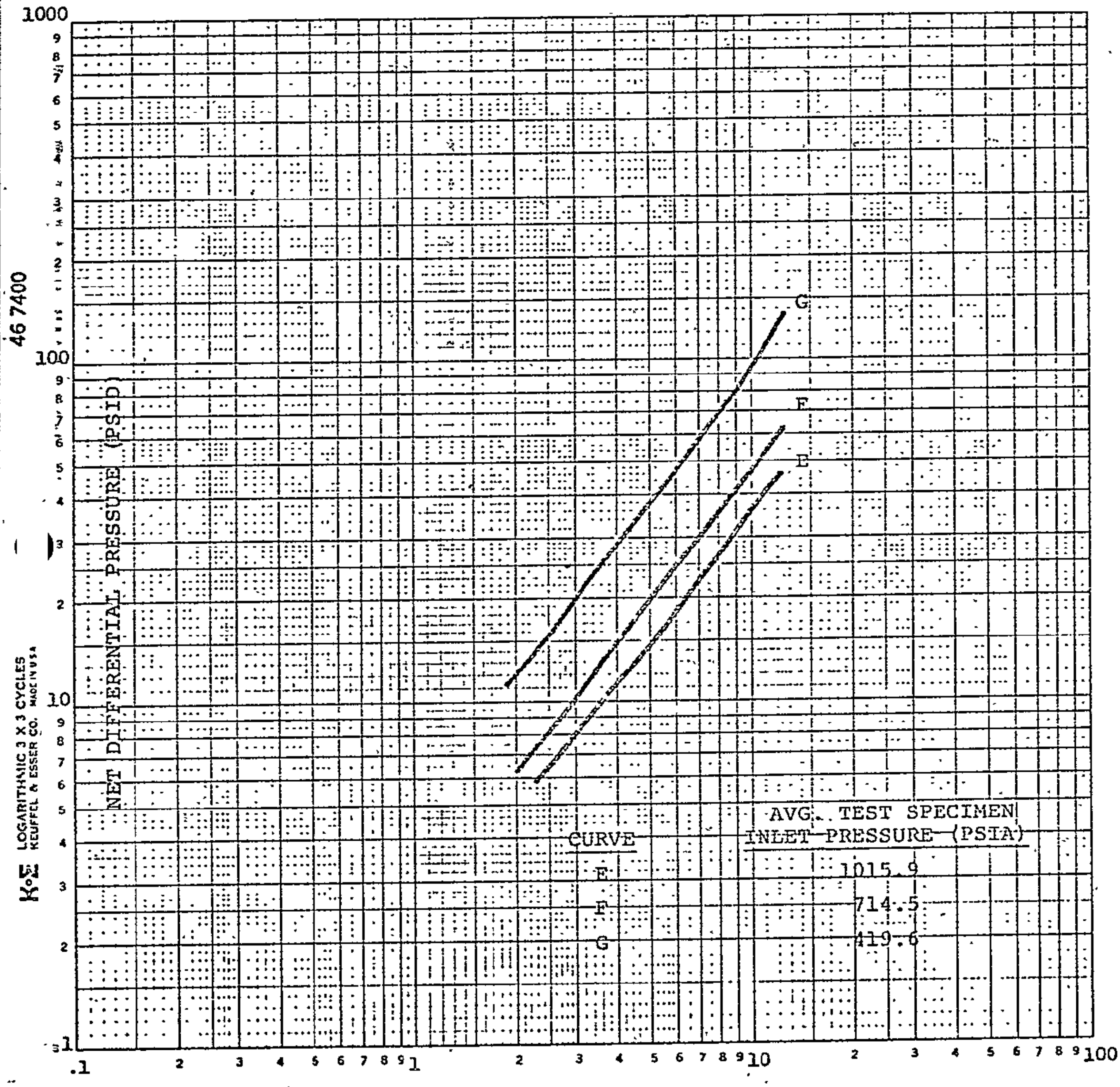
FLOW RATE (SCFM)

TEST NO. 6 Figure 69

TEST SPECIMEN S/N 021

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE VERSUS DIFFERENTIAL PRESSURE DATA AFTER 100 (10,000 PSIA NOMINAL) GN_2 IMPACT CYCLES



2-3

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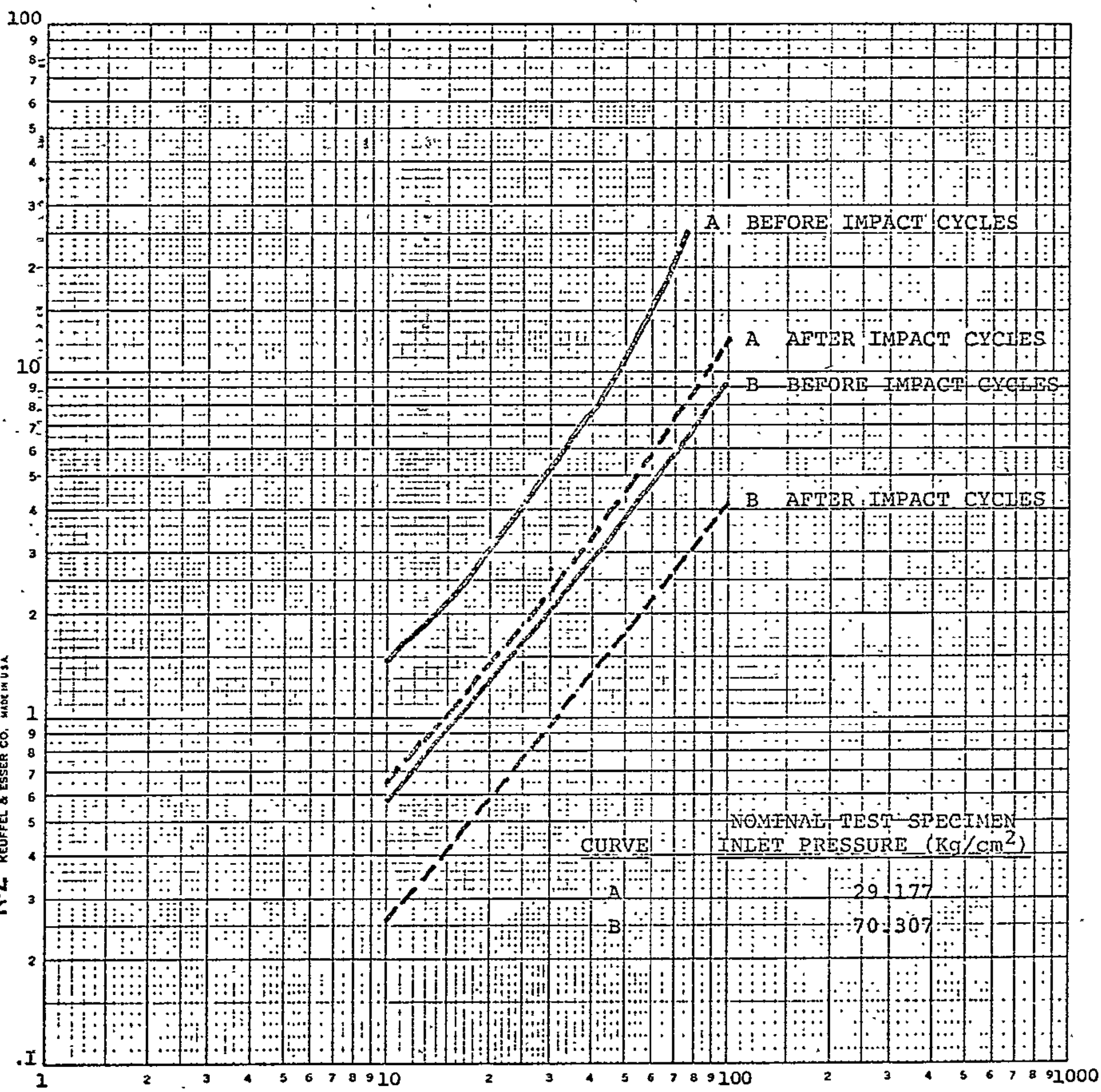
Figure 70

TEST NO. 5

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

PRESSURE DROP CHARACTERISTICS OF TEST SPECIMEN S/N 021 BEFORE AND AFTER 100 (703.07 Kg/cm^2 NOMINAL) GN_2 IMPACT CYCLES



FLOW RATE (liters* GN_2/min)

*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

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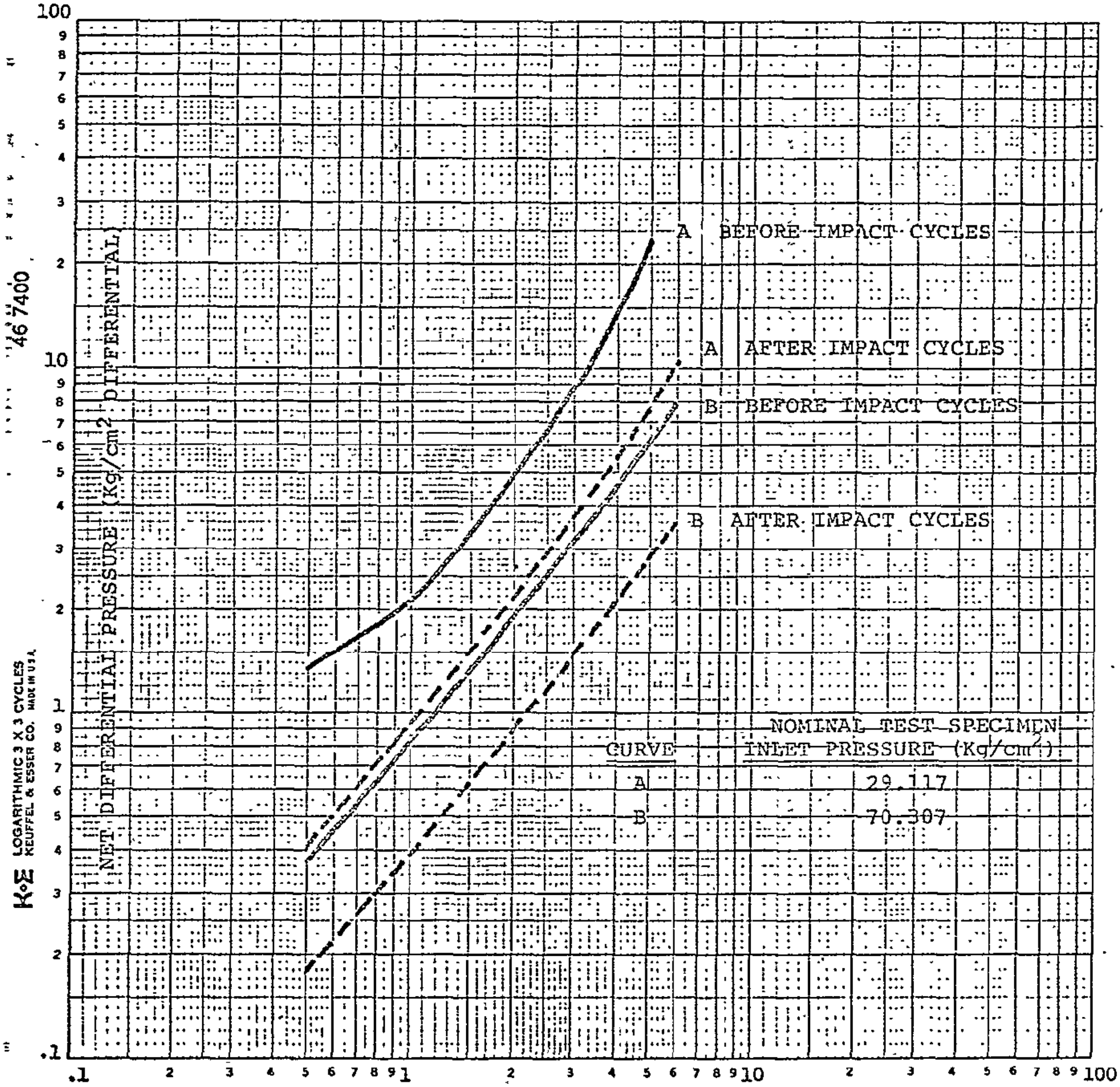
TEST NO. 5

Figure 7-1

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

PRESSURE DROP CHARACTERISTICS OF TEST SPECIMEN S/N 021 BEFORE AND AFTER 100 (703.07 Kg/cm^2 NOMINAL) GN_2 IMPACT CYCLES



FLOW RATE (Kg GN_2/hr)

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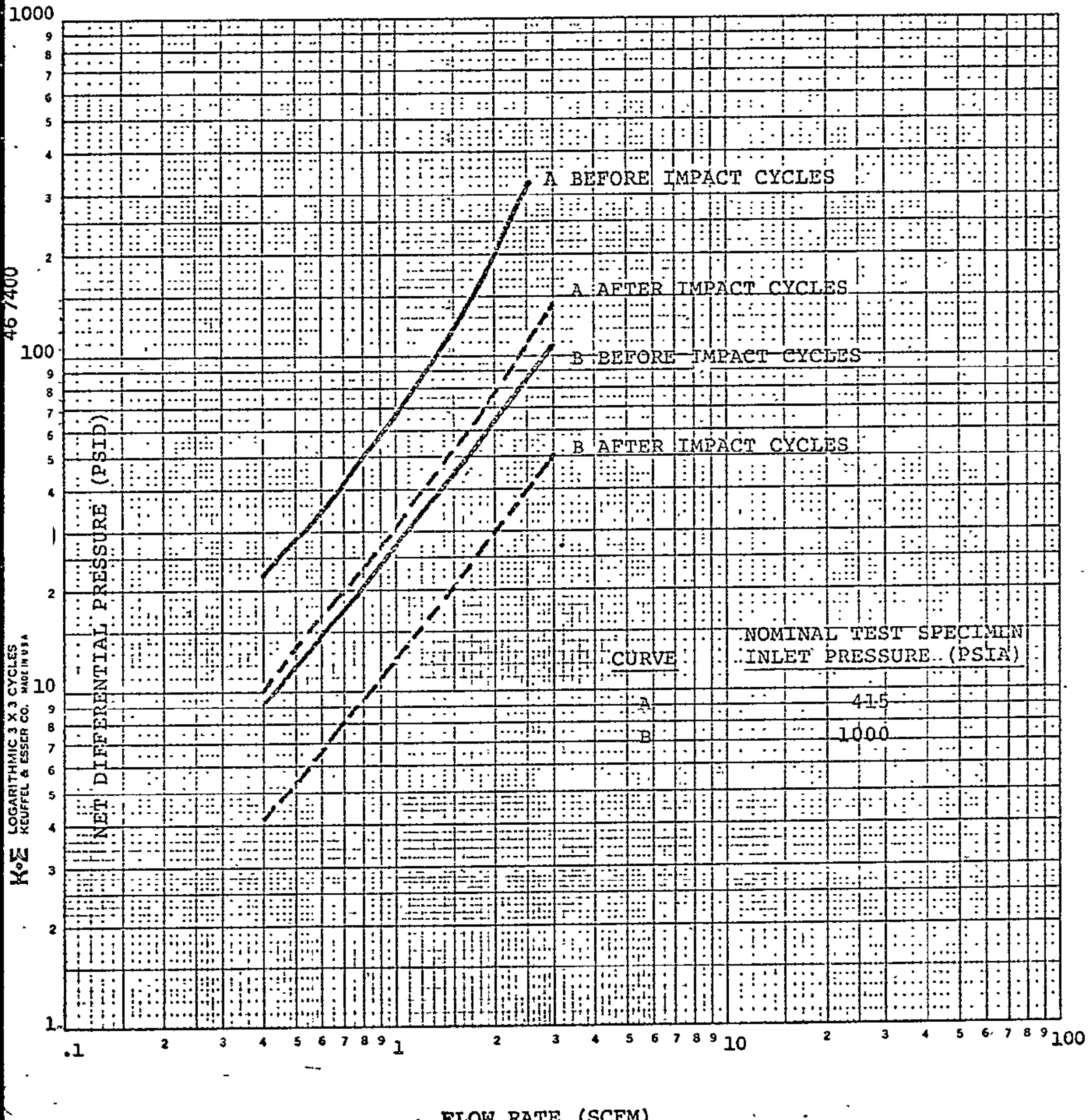
TEST NO. 5 Figure 72

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

PRESSURE DROP CHARACTERISTICS OF TEST SPECIMEN S/N 021 BEFORE AND AFTER 100 (10,000 PSIA NOMINAL) GN_2 IMPACT CYCLES



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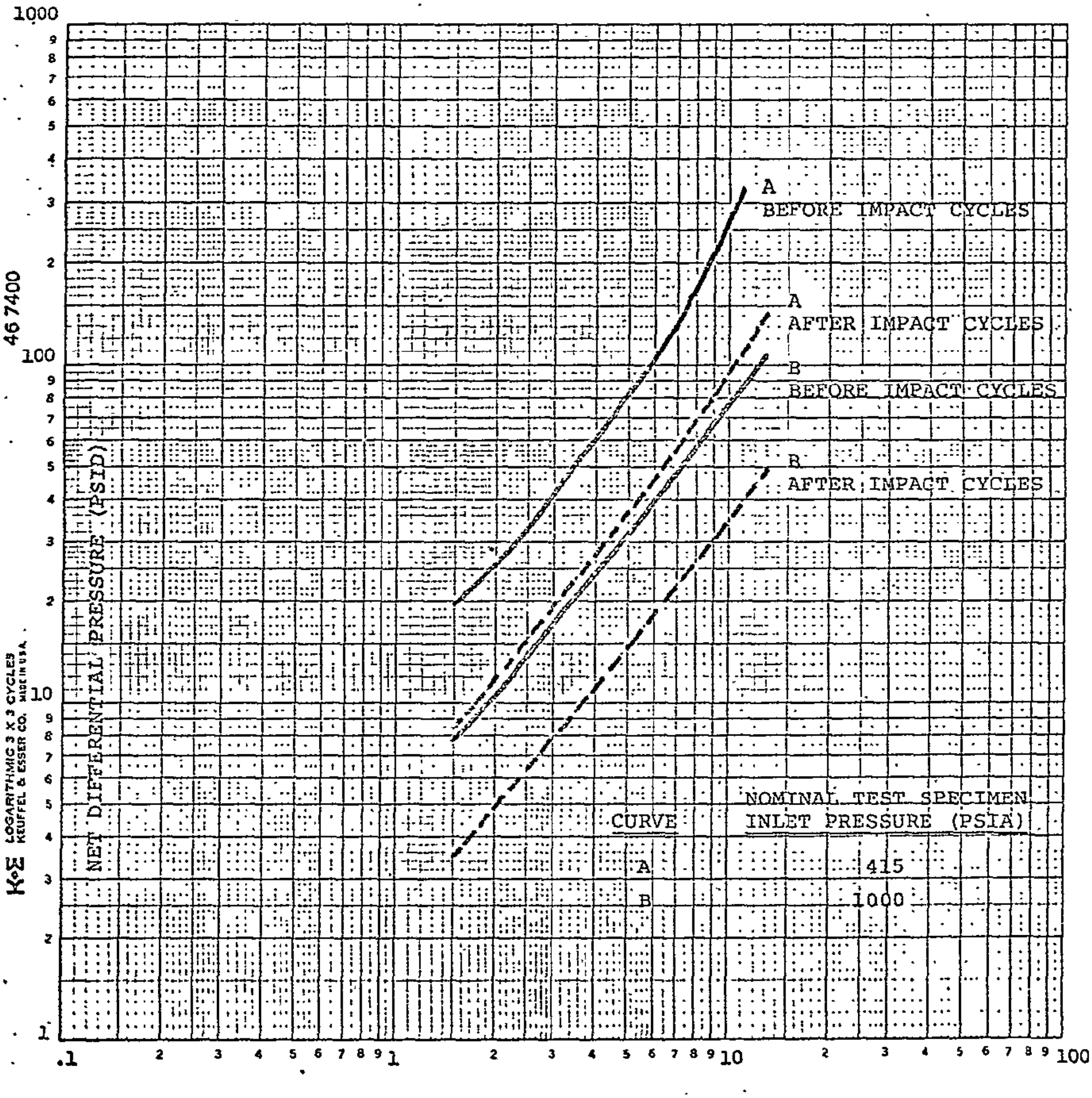
TEST NO. 5

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

PRESSURE DROP CHARACTERISTICS OF TEST SPECIMEN S/N 021 BEFORE AND AFTER 100 (10,000 PSIA NOMINAL) GN_2 IMPACT CYCLES



TEST NO. 6 Table XLVI

TEST SPECIMEN S/N 021

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE VERSUS DIFFERENTIAL PRESSURE DATA AFTER 100 [703.07 Kg/cm^2 NOMINAL] GN_2 IMPACT CYCLES

FLOW RATE (liters* GN_2/min)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential)		
	TEST SPECIMEN INLET PRESSURE (Kg/cm^2)		
	29.504^A	50.235^B	71.423^C
10	0.640	0.344	0.260
15	1.018	0.547	0.414
20	1.425	0.766	0.580
25	1.862	0.999	0.756
30	2.331	1.245	0.940
35	2.831	1.502	1.133
40	3.364	1.771	1.333
45	3.931	2.049	1.540
50	4.531	2.337	1.754
55	5.165	2.635	1.974
60	5.834	2.941	2.200
65	6.540	3.256	2.432
70	7.281	3.579	2.669
75	8.059	3.910	2.911
80	8.875	4.249	3.159
85	9.729	4.595	3.411
90	10.621	4.948	3.668
95	11.553	5.309	3.930
100	12.525	5.677	4.196

*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (Kg/cm}^2\text{ differential)} = a + b\,(\text{log liters GN}_2\text{/min}) + c\,(\text{log liters GN}_2\text{/min})^2 + d\,(\text{log liters GN}_2\text{/min})^3 + e\,(\text{log liters GN}_2\text{/min})^4$$

A. $\text{Log (Kg/cm}^2\text{ differential)} = -1.457866 + 1.529421\,(\text{log liters GN}_2\text{/min}) - 0.405005\,(\text{log liters GN}_2\text{/min})^2 + 0.139604\,(\text{log liters GN}_2\text{/min})^3$

Sigma = 0.030

B. $\text{Log (Kg/cm}^2\text{ differential)} = -1.499668 + 0.946370\,(\text{log liters GN}_2\text{/min}) + 0.090255\,(\text{log liters GN}_2\text{/min})^2$

Sigma = 0.018

C. $\text{Log (Kg/cm}^2\text{ differential)} = -1.648694 + 0.991528\,(\text{log liters GN}_2\text{/min}) + 0.072928\,(\text{log liters GN}_2\text{/min})^2$

Sigma = 0.009

Table XLVI

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

Table XLVII

TEST NO. 6

TEST SPECIMEN S/N 021

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE VERSUS DIFFERENTIAL PRESSURE AFTER 100
[703.07 Kg/cm^2 NOMINAL] GN_2 IMPACT CYCLES

	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential)		
	TEST SPECIMEN INLET PRESSURE (Kg/cm^2)		
($Kg\ GN_2/hr$)	29.504^A	50.235^B	71.423^C
0.5	0.403	0.223	0.176
1.0	0.937	0.499	0.388
1.5	1.531	0.812	0.627
2.0	2.189	1.155	0.889
2.5	2.915	1.524	1.170
3.0	3.714	1.917	1.468
3.5	4.589	2.332	1.783
4.0	5.544	2.767	2.113
4.5	6.583	3.221	2.457
5.0	7.707	3.694	2.815
5.5	8.922	4.183	3.185
6.0	10.231	4.689	3.568

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (Kg/cm}^2\text{ differential)} = a + b\,(\log \text{Kg GN}_2\text{/hr}) + c\,(\log \text{Kg GN}_2\text{/hr})^2 + d\,(\log \text{Kg GN}_2\text{/hr})^3 + e\,(\log \text{Kg GN}_2\text{/hr})^4$$

A. $\text{Log (Kg/cm}^2\text{ differential)} = -0.028075 + 1.201939\,(\log \text{Kg GN}_2\text{/hr}) + 0.008772\,(\log \text{Kg GN}_2\text{/hr})^2 + 0.206678\,(\log \text{Kg GN}_2\text{/hr})^3$

Sigma = 0.034

B. $\text{Log (Kg/cm}^2\text{ differential)} = -0.301694 + 1.184817\,(\log \text{Kg GN}_2\text{/hr}) + 0.083884\,(\log \text{Kg GN}_2\text{/hr})^2$

Sigma + 0.015

C. $\text{Log (Kg/cm}^2\text{ differential)} = -0.410913 + 1.168038\,(\log \text{Kg GN}_2\text{/hr}) + 0.089866\,(\log \text{Kg GN}_2\text{/hr})^2$

Sigma = 0.006

Table XLVII

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

TEST NO. 6 Table XLVIII

TEST SPECIMEN S/N 021

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE VERSUS DIFFERENTIAL PRESSURE DATA AFTER 100 [10,000 PSIA NOMINAL] GN_2 IMPACT CYCLES

FLOW RATE (SCFM)	NET DIFFERENTIAL PRESSURE (PSID) TEST SPECIMEN INLET PRESSURE (PSIA)		
	419.6[A]	714.5[B]	1015.9[C]
0.4	9.994	5.359	4.183
0.5	13.081	6.968	5.419
0.6	16.296	8.658	6.713
0.7	19.643	10.423	8.062
0.8	23.128	12.257	9.462
0.9	26.754	14.155	10.910
1.0	30.527	16.115	12.403
1.1	34.450	18.133	13.939
1.2	38.528	20.207	15.517
1.3	42.763	22.334	17.134
1.4	47.158	24.513	18.789
1.5	51.719	26.742	20.482
1.6	56.447	29.018	22.210
1.7	61.345	31.342	23.973
1.8	66.418	33.711	25.770
1.9	71.667	36.124	27.600
2.0	77.097	38.580	29.462
2.1	82.710	41.079	31.356
2.2	88.509	43.619	33.280
2.3	94.497	46.199	35.235
2.4	100.677	48.818	37.219
2.5	107.054	51.477	39.232
2.6	113.628	54.173	41.274
2.7	120.405	56.907	43.344
2.8	127.386	59.678	45.441
2.9	134.575	62.485	47.566
3.0	141.975	65.328	49.717
3.1	149.590	68.206	51.895
3.2	157.423	71.118	54.098
3.3	165.476	74.065	56.328
3.4	173.753	77.045	58.582
3.5	182.258	80.058	60.862

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{SCFM}) + c\,(\log \text{SCFM})^2 + d\,(\log \text{SCFM})^3 + e\,(\log \text{SCFM})^4$$

A. $\text{Log (PSID)} = 1.484688 + 1.260296\,(\log \text{SCFM}) + 0.189342\,(\log \text{SCFM})^2 + 0.212759\,(\log \text{SCFM})^3$

Sigma = 0.484

B. $\text{Log (PSID)} = 1.207233 + 1.234530\,(\log \text{SCFM}) + 0.082784\,(\log \text{SCFM})^2$

Sigma = 0.218

C. $\text{Log (PSID)} = 1.093530 + 1.221429\,(\log \text{SCFM}) + 0.088763\,(\log \text{SCFM})^2$

Sigma = 0.084

Table XLVIII

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

Table XLIX

TEST NO. 6

TEST SPECIMEN S/N 021

CLEAN CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE VERSUS DIFFERENTIAL PRESSURE DATA AFTER 100
[10,000 PSIA NOMINAL] GN_2 IMPACT CYCLES

FLOW RATE (lbs GN_2/hr)	NET DIFFERENTIAL PRESSURE (PSID) TEST SPECIMEN INLET PRESSURE (PSIA)		
	419.6^A	714.5^B	1015.9^C
1.0	5.066	2.846	2.248
1.5	8.377	4.522	3.542
2.0	11.859	6.327	4.930
2.5	15.509	8.245	6.399
3.0	19.336	10.262	7.942
3.5	23.345	12.373	9.553
4.0	27.545	14.569	11.227
4.5	31.941	16.845	12.960
5.0	36.539	19.198	14.750
5.5	41.344	21.623	16.594
6.0	46.362	24.117	18.489
6.5	51.597	26.678	20.434
7.0	57.054	29.302	22.426
7.5	62.739	31.989	24.465
8.0	68.655	34.736	26.548
8.5	74.807	37.541	28.675
9.0	81.201	40.403	30.844
9.5	87.839	43.320	33.055
10.0	94.727	46.290	35.306
10.5	101.870	49.314	37.596
11.0	109.272	52.389	39.925
11.5	116.938	55.514	42.292
12.0	124.872	58.689	44.696
12.5	133.079	61.912	47.136
13.0	141.564	65.183	49.612
13.5	150.331	68.500	52.123
14.0	159.386	71.864	54.669
14.5	168.733	75.273	57.249
15.0	178.377	78.726	59.863

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{lbs } GN_2/hr) + c\,(\log \text{lbs } GN_2/hr)^2 + d\,(\log \text{lbs } GN_2/hr)^3 + e\,(\log \text{lbs } GN_2/hr)^4$$

A. $\text{Log (PSID)} = 0.704640 + 1.270367\,(\log \text{lbs } GN_2/hr) - 0.206283\,(\log \text{lbs } GN_2/hr)^2 + 0.207751\,(\log \text{lbs } GN_2/hr)^3$

Sigma = 0.478

B. $\text{Log (PSID)} = 0.454185 + 1.27636\,(\log \text{lbs } GN_2/hr) + 0.083670\,(\log \text{lbs } GN_2/hr)^2$

Sigma = 0.216

C. $\text{Log (PSID)} = 0.351782 + 1.105770\,(\log \text{lbs } GN_2/hr) + 0.090291\,(\log \text{lbs } GN_2/hr)^2$

Sigma = 0.084

Table XLIX

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Table 1

TEST NO. 6

TEST SPECIMEN S/N 021

TYPICAL GN_2 IMPACT PRESSURE DATA

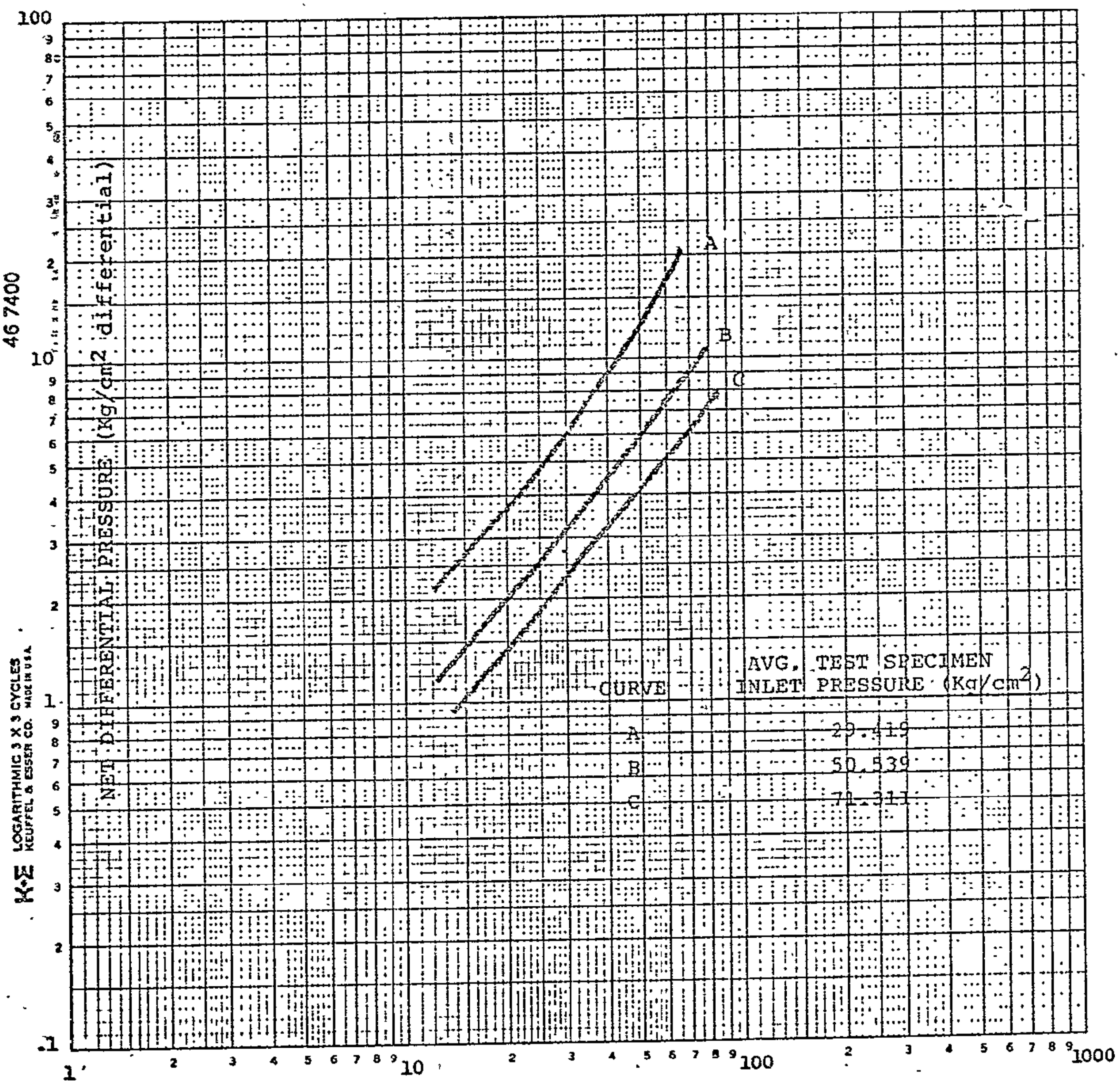
IMPACT NO.	PRESSURE UPSTREAM OF ECV-1 PT-2 (PSIA)	PT-12 KISTLER PEAK PRESSURE UPSTREAM OF TEST SPECIMEN	RATIO OF PEAK IMPACT PRESSURE TO ECV-1 INLET PRESSURE
1	10,440	9,458	0.906
5	10,500	9,458	0.901
10	10,540	9,425	0.894
15	10,500	9,442	0.899
20	10,360	9,301	0.898
25	10,540	9,491	0.900
30	10,560	9,632	0.912
35	10,590	9,577	0.904
40	10,470	9,480	0.905
45	10,490	8,554	0.815
50	10,730	9,460	0.882
55	10,510	9,217	0.877
60	10,530	9,137	0.868
65	10,540	9,164	0.869
70	10,480	9,212	0.879
75	10,510	9,241	0.879
80	10,520	9,273	0.881
85	10,680	9,599	0.899
90	10,555	9,534	0.903
95	10,520	9,371	0.891
100	10,540	9,490	0.900

Figure 74

TEST NO. 5

TEST SPECIMEN S/N 022

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE



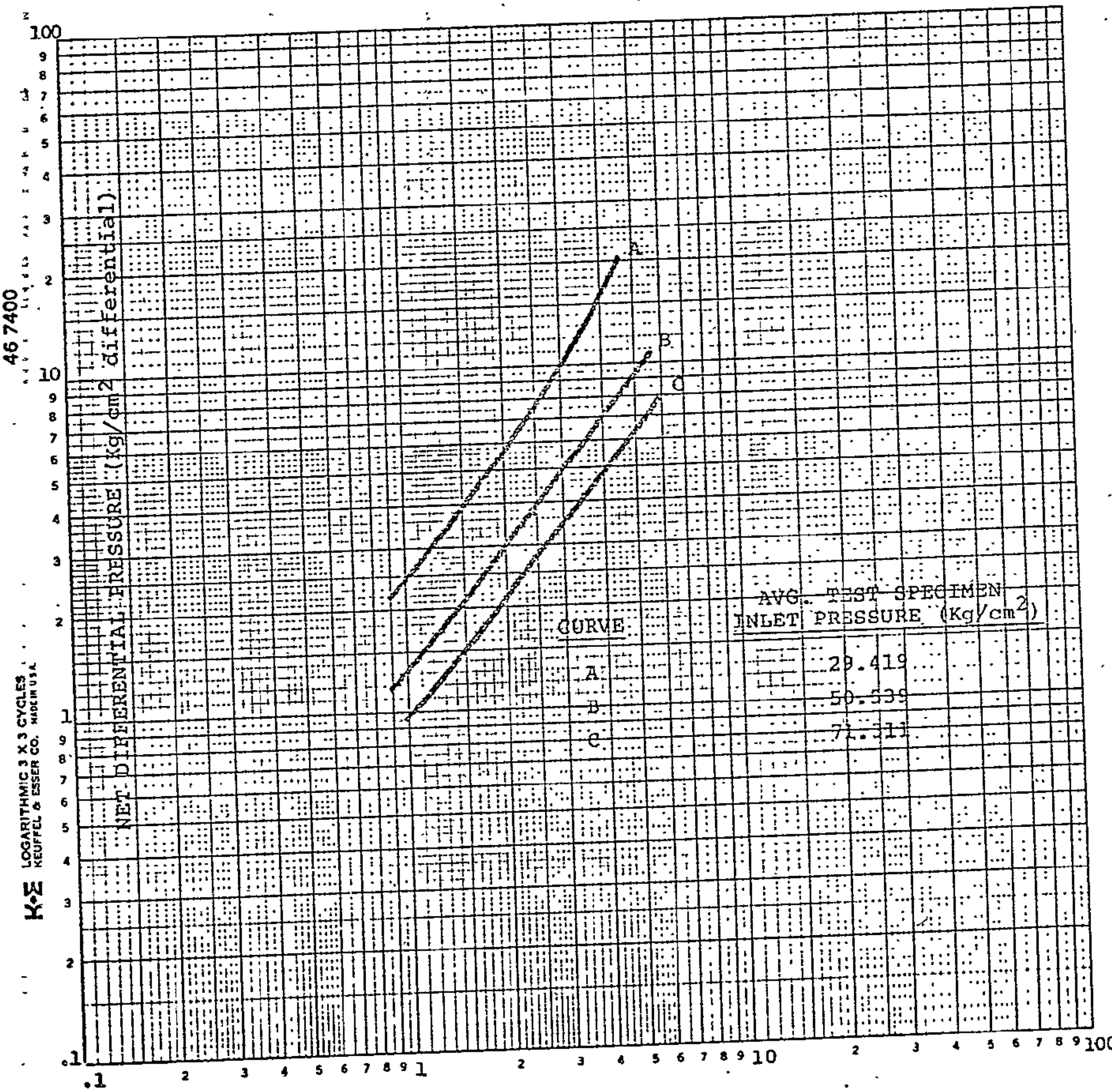
*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

Figure 75

TEST NO. 5

TEST SPECIMEN S/N 022

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE



FLOW RATE (Kg GN_2/hr)

TEST NO. 5

Figure 76

TEST SPECIMEN S/N 022

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

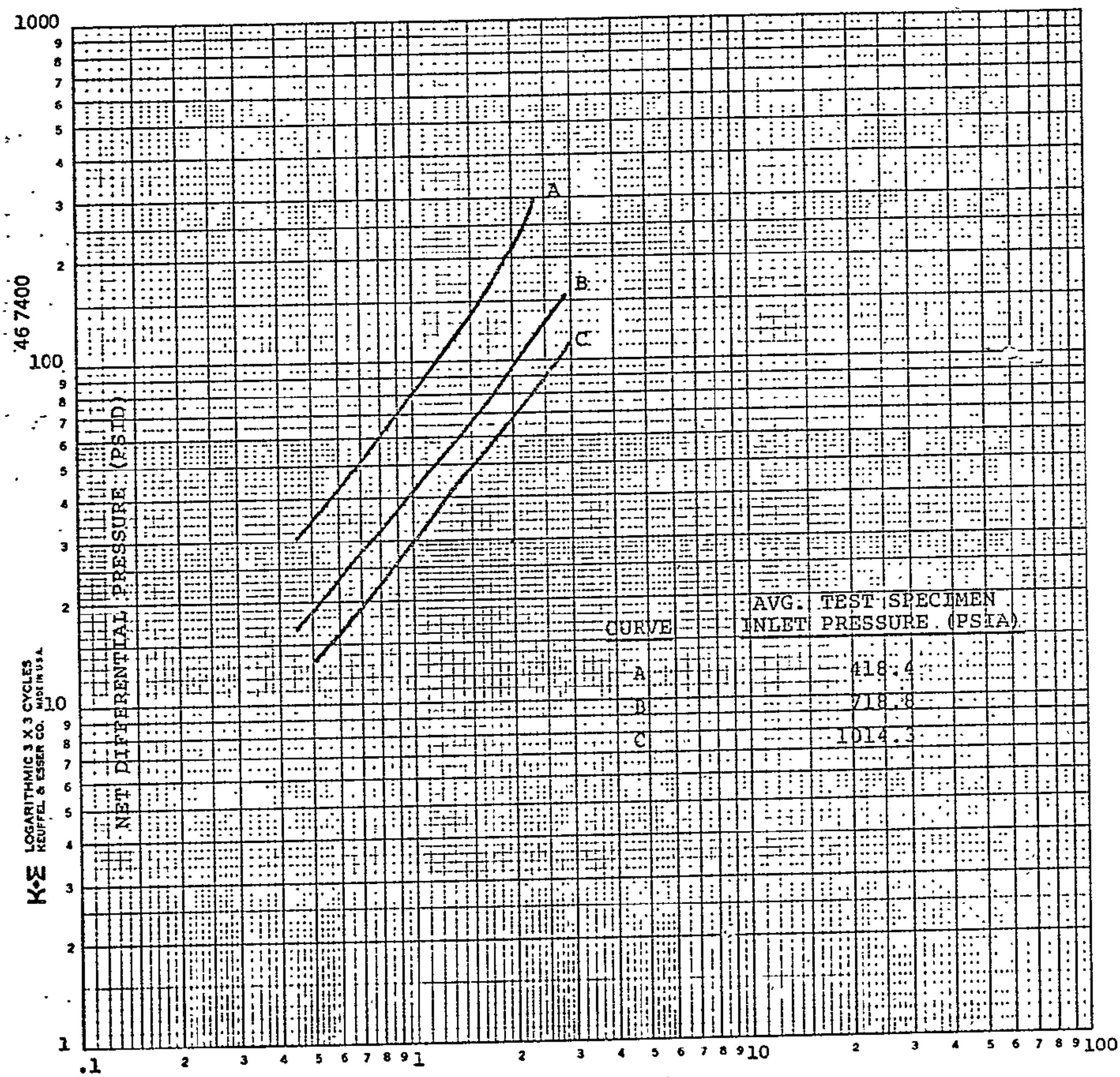


Figure 77

TEST NO. 5

TEST SPECIMEN S/N 022

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE